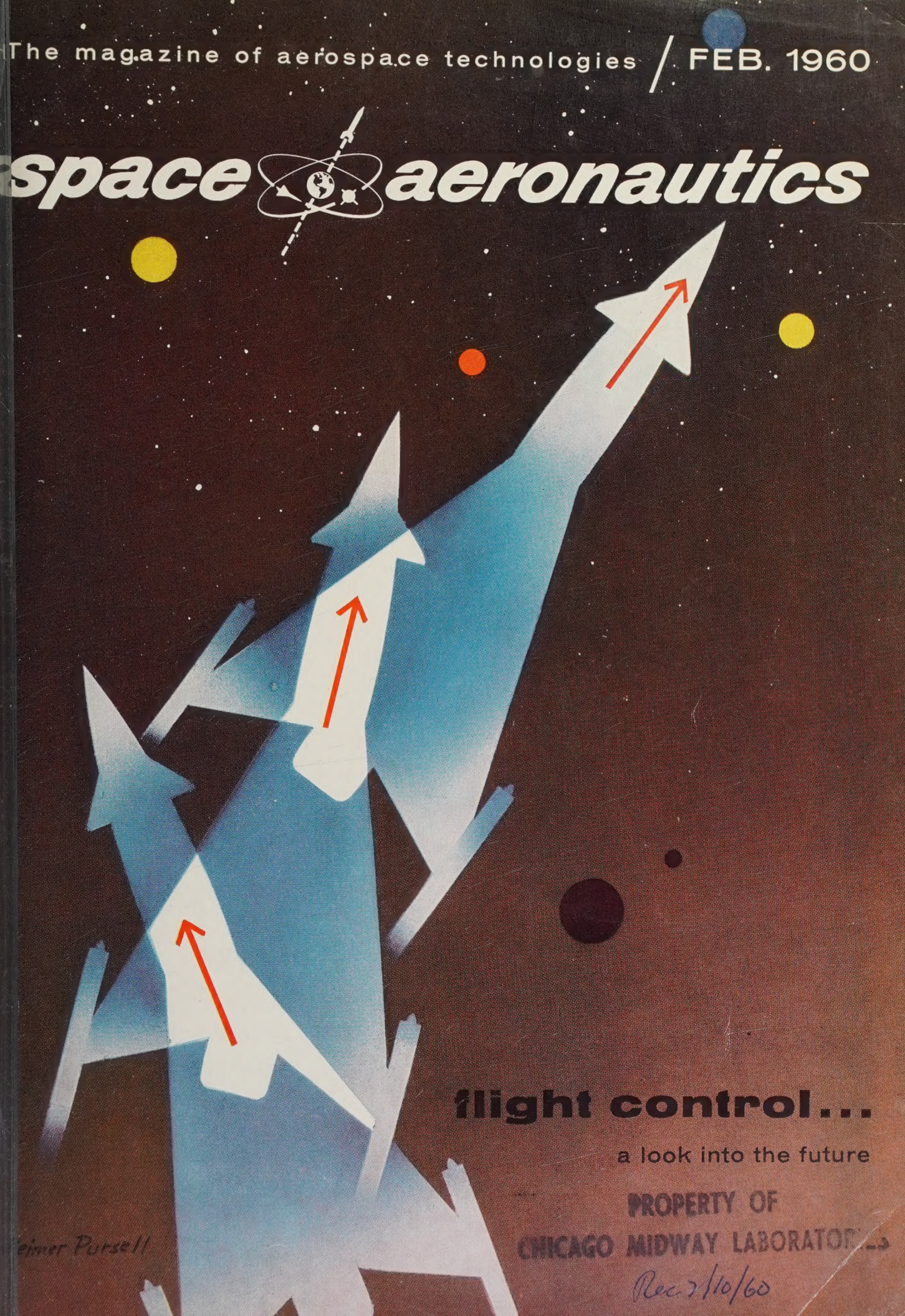
The magazine of aerospace technologies / FEB. 1960

space aeronautics



flight control...

a look into the future

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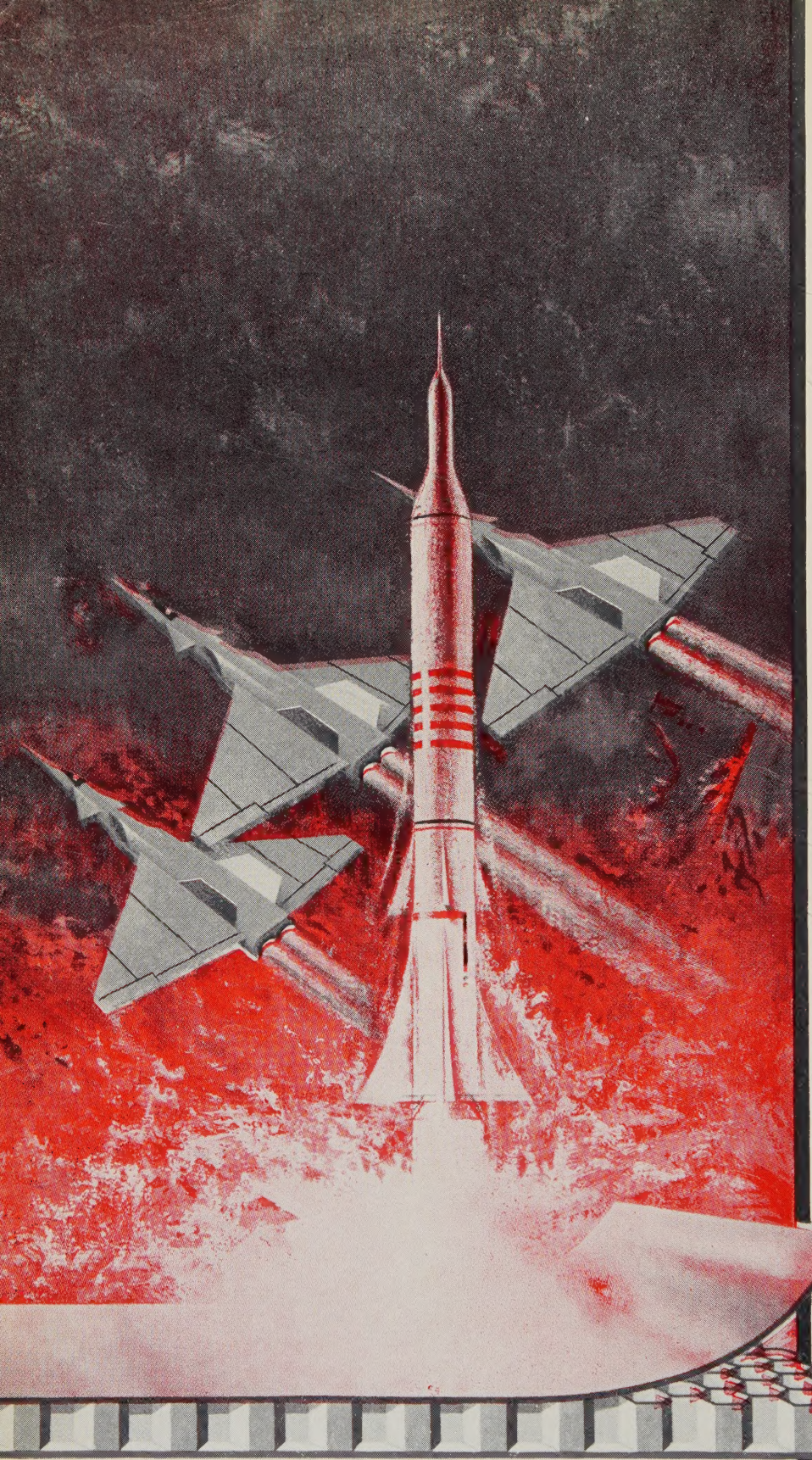

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wary watchman for

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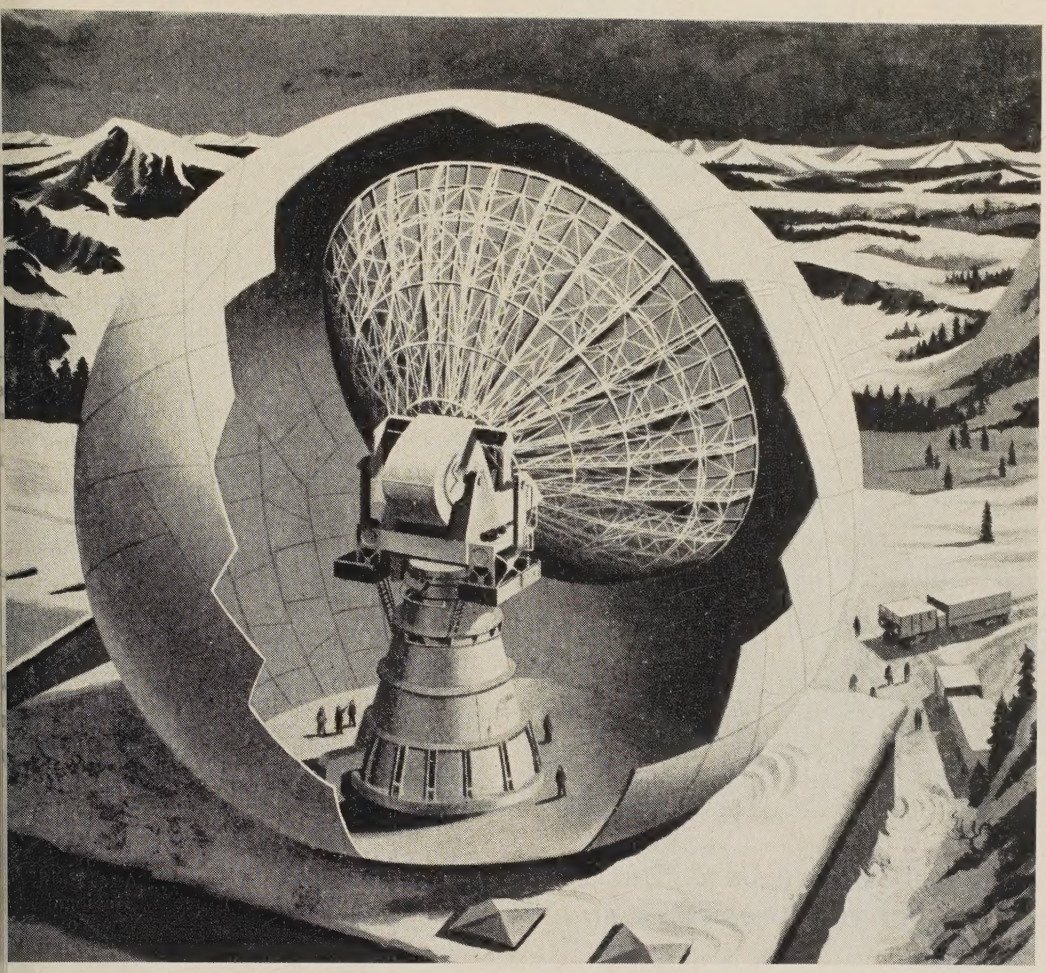

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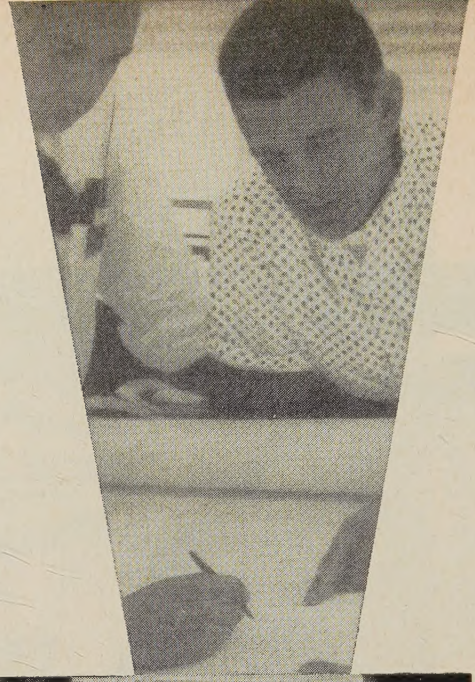

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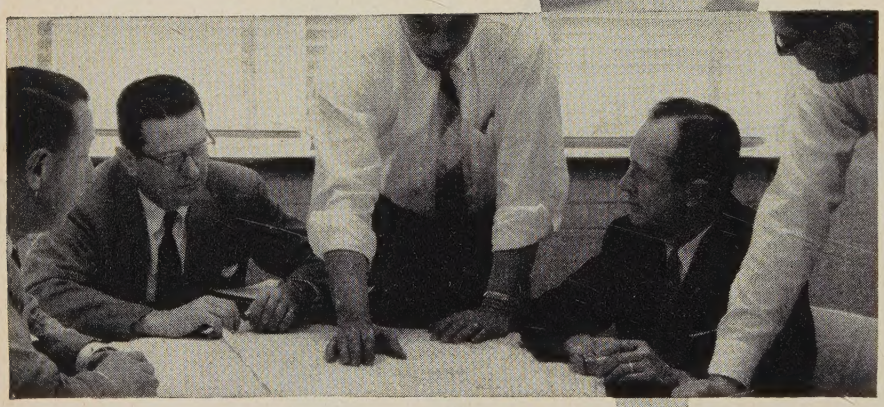

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space/aeronautics

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ıme any terrain with this Goodyear team. Famous rra-Tires and Rolli-Tankers pair up to give any weapon stem the "rollpower" it needs for fast, go-anywhere ɔbility.

rrain that stops tanks and other vehicles in their tracks and, snow, deep mud—or even rough and rocky grades—n't halt the Terra-Tire. Secret is its broad, flat "foot-int" that rolls easily over soft, unstable surfaces without gging in. These superstrong Terra-Tires carry heavy pay ds into areas barred to other vehicles — yet their ride is gentle that fragile equipment is cushioned from shock.

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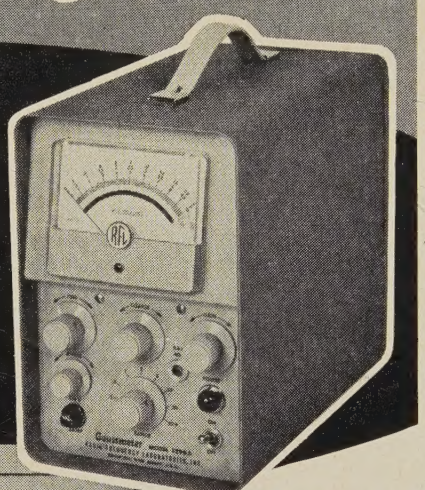
GOODYEAR

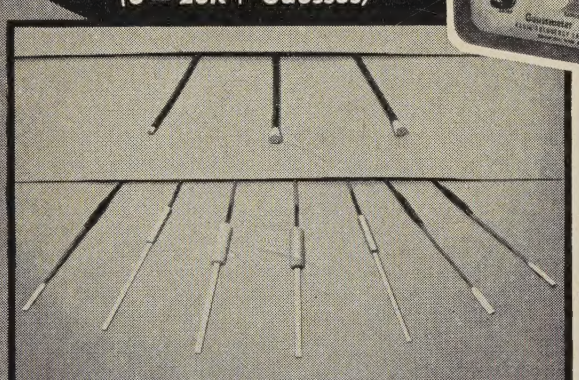
Terra-Tire, Rolli-Tanker—T. M.'s The Goodyear Tire & Rubber Company, Akron, Ohio

Analyze Magnetic Circuits

Model 1295A provides NINE FULL-SCALE Ranges

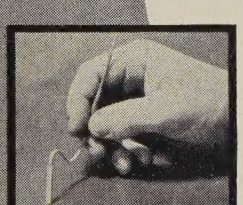
(0 – 20K+ Gausses)





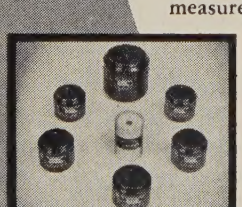
This Gaussmeter employs temperature stabilizing transistor circuits and a full set of balancing controls for fine adjustment. Readings are accurate to ±3%, repeatable within 1%; accuracy can be increased to ±1% at most points using special reference magnets. Magnetic fields from DC to 400 cps can be measured.

Ten Probes Fit Most Magnet Gaps



Each of the probes shown will work from 0 to 20K+ gausses with the Model 1295A. Since no single probe will fit all magnet configurations, a selection of Bi and InAs elements, rigid or flexible shafts, and flat or axial tips varying from .010" to 0.312" thick is available to meet most applications.

With the Model 1295A and any probe, it's easy to make direct measurements of gap flux density; analyze location, homogeneity, direction and intensity of stray fields in magnetic circuits. Formula predictions can be checked by direct measurement.



Probe Reference Magnets

The 1000-gauss ±¾% flat probe ref. magnet supplied with the Model 1295A is sufficient to maintain the ±3% system accuracy over all ranges. Other values from 200 to 10K gausses, including axial fields, are also available. All magnets are properly stabilized and shielded.

Net price of Model 1295A with reference magnet (without probe) is $390. f.o.b. Boonton, N.J. Probes from $30. to $180.

SEND FOR TECH. DATA

For additional information, including application data, write or phone DE 4-3100. Demonstrations available by local representatives.

RFL Radio Frequency LABORATORIES, INC. Boonton, New Jersey, U.S.A.

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cover story

What does the future hold for flight control? This question is posed, so to speak, by artist Weimer Pursell on the cover this month and answered in the comprehensive article beginning on *page 46*. Design breakthroughs will be needed in several areas, this article points out: in vernier control, in materials and lubricants, in "all-altitude operation" (inside and outside the atmosphere), and in boundary layer control. The article also includes extensive illustrations showing, among other detail, the basic electronic features of future control systems and two complete control systems for hypersonic aircraft.

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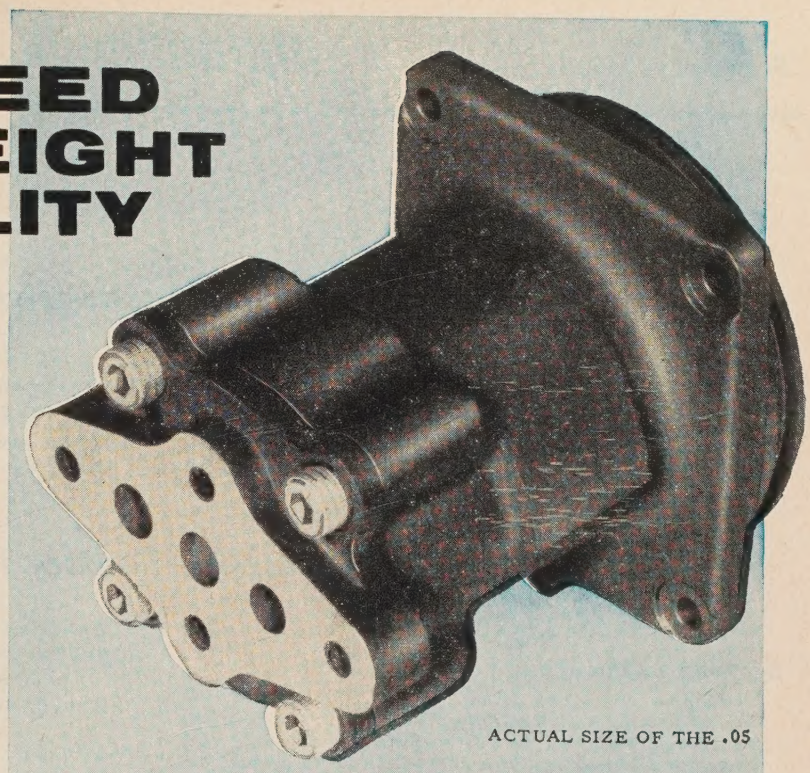

ACTUAL SIZE OF THE .05

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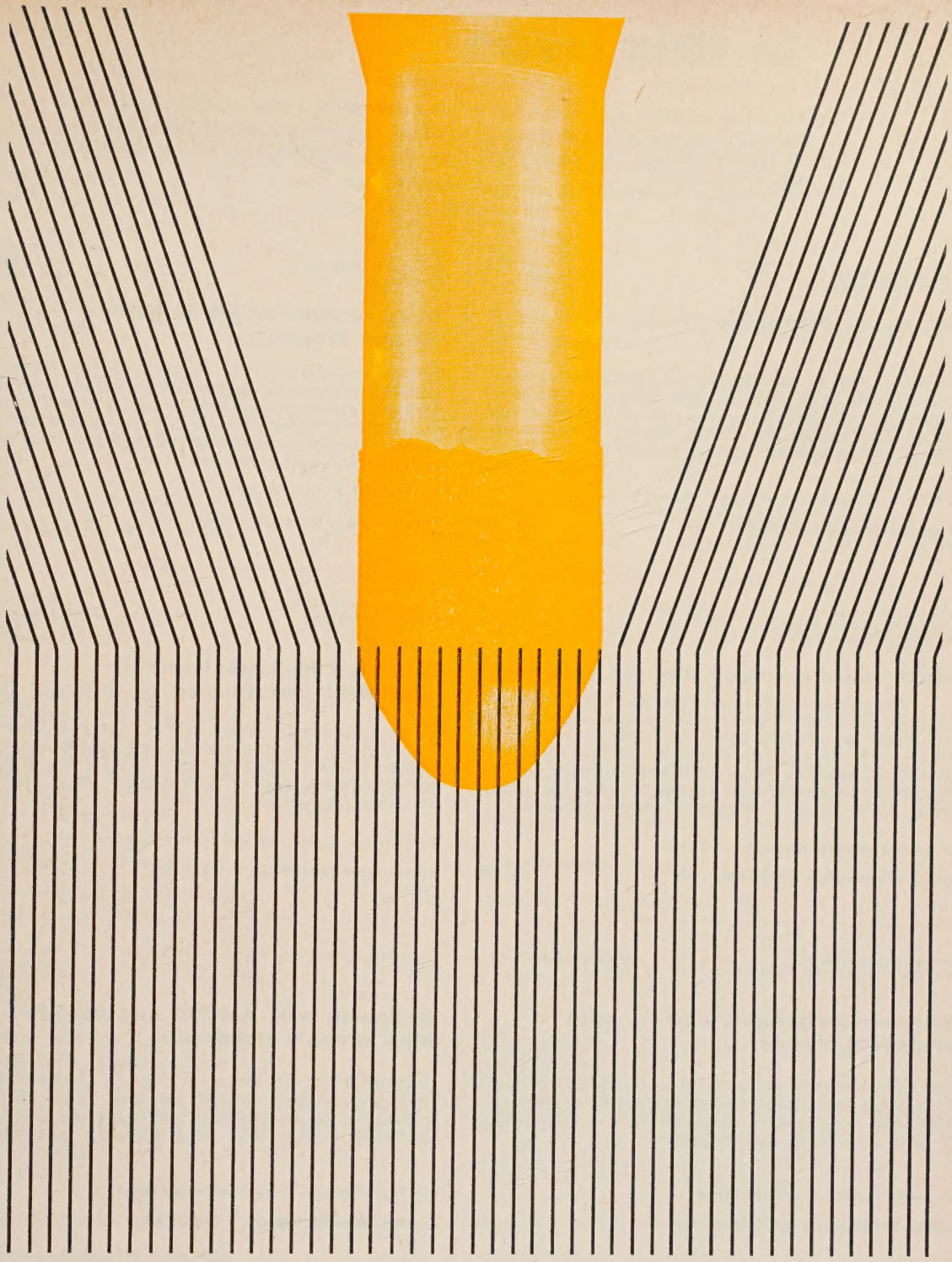

Avco cools a nose cone—at 12,000°F. — To bring a space vehicle safely through the 12,000-degree heat of atmospheric re-entry, Avco scientists have developed radically new "space age materials." One of these, a ceramic structure termed Avcoite, made history as it returned this country's first successfully recovered ICBM nose cone. Today, materials research at Avco continues in new and bold directions, ranging from heat-resistant rocket nozzles to lightweight space structures.

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in this issue

Here's a quick rundown of the technical information offered in the articles in this issue. You can also use these article abstracts to build up your own permanent record for reference in the future—just clip them, paste them up on standard three-by-five cards, and file them.

Aerospace Engineering
Systems Engineering

Astia code: 2-1
Your code:

Landing on the moon

Review of design requirements and problems involved in "hard" and "soft" lunar impacts. Application of liquid and solid propellant rocket engines is discussed, and special requirements for descent control, shock absorption, and radio transmission are pointed up.

by Kurt R. Stehling, Contributing Technical Editor

space/aeronautics 33/2 (Feb. '60) p. 42

Aerospace Engineering
Propulsion

Astia code: 27-2
Your code:

Design details of J79 turbojet (Design Progress)

Internal arrangement of J79 and CJ-805 (commercial version) are shown, together with major components. Included are: front compressor casing assembly, showing variable vanes; air distribution system and parts layout; unique aerodynamic exhaust nozzle operation; turbine rotor with conical shaft.

by Randolph Hawthorne, Editor

space/aeronautics 33/2 (Feb. '60) p. 59

Aerospace Engineering
Systems Engineering, Dynamics, Propulsion, Acessory Systems

Astia code: 1-1, -2; 8-2; 27-2, -3
Your code:

Flight controls: a look into the future

Analysis of future flight control system requirements and design possibilities based on trends in powerplant and vehicle development. Discusses jet flap control to 100,000 ft, reaction jets, controllable turbojet nozzles, and vernier control systems for operation in the atmosphere and in space. Considers speeds to Mach 18.

by Harry E. Arnzen, Republic Aviation

space/aeronautics 33/2 (Feb. '60) p. 46

Aerospace Engineering
Systems Engineering

Astia code: 1-2
Your code:

Grumman Mohawk features short-field performance

Design analysis of Army YAO-1 Mohawk observation plane. Basic design objectives and approaches are explained. Details are given on structural and equipment features. Specifications, performance data, and three-view are presented.

by Homer U. Tsakis, Grumman Aircraft Engineering

space/aeronautics 33/2 (Feb. '60) p. 65

Aerospace Engineering
Production Engineering, Propulsion

Astia code: 26-1; 27-3
Your code:

Bottom-casting forms narrow solid propellant shapes

Description of method for making solid propellant shapes by using a pressurized rubber diaphragm to force the propellant up into the rocket case cavity. This method is used with long, narrow grains.

by Irwin Stambler, Associate Editor

space/aeronautics 33/2 (Feb. '60) p. 50

Aerospace Engineering
Materials

Astia code: 17-4
Your code:

Designing with AM-350 and AM-355 high strength stainless

State-of-the-art discussion of Allegheny Ludlum AM-350 and AM-355 high strength stainless steels. Mechanical properties and various heat treatments are given as well as details of new cold-rolled tempers.

by T. H. McGunn, Allegheny Ludlum Steel

space/aeronautics 33/2 (Feb. '60) p. 79

Aerospace Engineering
Systems Engineering, Dynamics, Structures, Testing

Astia code: 12
Your code:

Hound Dog designed for off-the-shelf reliability

Design study of North American GAM-77 Hound Dog air-to-surface missile. Sketches and pictures of structural design are shown. Aerodynamics, GSE, and other special design aspects are discussed.

by Irwin Stambler, Associate Editor

space/aeronautics 33/2 (Feb. '60) p. 54

Aerospace Engineering
Production Engineering

Astia code: 26-1
Your code:

Spark-bomb method promises in-plant explosive forming

Description of new high energy rate forming process that uses a shock wave (induced in a liquid by electric energy) to form parts. It permits forming in production plants without special pits or outdoor installations. A typical circuit diagram is shown.

by Irwin Stambler, Associate Editor

space/aeronautics 33/2 (Feb. '60) p. 99

To make filing easier, each abstract is coded according to the Astia Distribution Guide. Copies of this guide are available from Armed Services Technical Information Agency, Arlington Hall Sta., Arlington 12, Va. There is also room on the abstracts for you to insert your own key if you use a special coding system.

Aerospace Engineering
Testing

Astia code: 30-4
Your code:

Building your own combined environment test fixture

Description of test fixture for simulating the combined missile environments produced during engine firing and the first seconds of flight. The fixture, built from commercially available parts, was designed specifically to test a small valve flowing helium at cryogenic temperatures.

by O. B. Farley & F. J. Fellows, AiResearch Mfg. Co. of Arizona

space/aeronautics 33/2 (Feb. '60) **p. 103**

Aerospace Electronics

Astia code: 8-6
Your code:

Powering recon platforms with microwaves (Design Digest)

Analysis of design techniques and problems involved in a proposed plan to maintain high altitude hovering platforms with power from ground-based microwave transmissions. Power generation and transmission, Raytheon's amplitron design, and the hovering vehicle's requirements are outlined.

by Bernard Kovit, Associate Electronics Editor

space/aeronautics 33/2 (Feb. '60) **p. 145**

Aerospace Engineering
Propulsion, Accessory Systems, Ground Support

Astia code: 27-2
Your code:

Water injection gives F-105 2000 lb extra thrust

Schematics and operational description of the water injection system designed for the F-105. Includes drawings and operation diagram of the ground servicing and water demineralizing unit.

by Victor de Biasi, Associate Editor

space/aeronautics 33/2 (Feb. '60) **p. 119**

Aerospace Electronics
Pages from an Engineer's Notebook

Astia code: 8-5
Your code:

Figuring frequency from CRO patterns

A handy nomogram for which you only need the sweep speed of the scope, the divisions per cycle, and a straightedge. From these, you can immediately obtain the display frequency and its period.

by Donald Moffat, Motorola

space/aeronautics 33/2 (Feb. '60) **p. 149**

Aerospace Electronics

Astia code: 19-3
Your code:

Industry pushes work on low altitude radar altimeter

Discussion of current low altitude absolute altimeter designs and developments, covering quantized and unquantized FM-CW phase-CW, pulse radar, and sonic types. Step error is explained. AIL table gives data on 11 altimeters.

by James Holahan, Electronics Editor

space/aeronautics 33/2 (Feb. '60) **p. 134**

Aerospace Electronics

Astia code: 8-1
Your code:

RSW antenna mates UHF radar to AEW aircraft

Description of the retarded-surface-wave antenna and its advantages for airborne UHF radar. Data obtained in tests of 1/12- and 1/6-scale models are given. Plots of antenna azimuth and elevation patterns, antenna gain, VSWR, and sidelobe level are included.

by E. H. Flath & E. G. Keiffer, Chance Vought

space/aeronautics 33/2 (Feb. '60) **p. 151**

Aerospace Electronics

Astia code: 8-3; 22-7
Your code:

Acceleration ranging: target distance from passive detector

A method of obtaining range using a passive detector and ownership motion sensors is described. Equations that have to be solved by the vehicle's fire control computer are derived. Three numerical examples are given.

by C. V. R. Townsend & R. O. Sisson, General Electric

space/aeronautics 33/2 (Feb. '60) **p. 139**

Reprints on Undersea Systems

A considerable number of orders has already been received for reprints of the special report on Undersea Weapon Systems from the January issue. Since the supply is limited, we urge you that you place your order immediately if you have been planning to get a reprint. Single-copy and small-lot orders will be filled free of charge. Reprints of the four-color map of the North Atlantic undersea environment, which accompanied the report, are available at $1 each. For bulk orders—on both the special report and the map—special rates will be quoted upon request. Address all correspondence to Reprint Dept., Space/Aeronautics, 205 E. 42nd St., New York 17, N. Y.

STEPS IN THE RACE TO OUTER SPACE

Atomic Pulse Rocket

This is the Atomic Pulse Rocket, a pot-bellied space ship nearly the size of the Empire State Building, propelled by a series of atomic blasts.

The enormous rocket (weighing 75,000 tons fully loaded) is designed to leave Earth with a thrust of 100,000 tons. Altogether a thousand atomic blasts—each equal to 1,000 tons of TNT—are fired from a low velocity gun into a heavy steel rocket engine at a rate of one per second until the vehicle leaves Earth's atmosphere. Then steam and vaporized steel maintain the thrust. After transit speed is reached, and the propulsion system shut off, power is provided by solar batteries plating the wing and body surfaces.

Inside the rocket, living quarters are situated in the rim of a pressurized wheel-like cabin which revolves to provide artificial gravity. Radio and radar antennae revolve with it. Tubular hydroponic "gardens" on either side of the rim grow algae to produce oxygen and high protein food.

The Atomic Pulse Rocket could transport payload to the Moon at $6.74 per lb., less than one quarter the prevailing air freight charges over equivalent distance.

A similar project is past the pilot-study stage in the Defense Department.

ARMA, now providing the inertial guidance system for the ATLAS ICBM and engaged in advanced research and development, is in the vanguard of the race to outer space. For this effort, ***ARMA*** needs scientists and engineers experienced in astronautics. ***ARMA***, Garden City, New York. A Division of American Bosch Arma Corporation.

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IN A WAY, "secondary power systems" is a misnomer—for a number of advanced vehicle designs, the secondary power system threatens to become the primary obstacle. To bring you up to date on the latest developments in secondary power and on what we can expect from them, SPACE/AERONAUTICS will start a detailed, two-part survey of the state of the art.

THREE of the most promising "exotic" metals will be discussed extensively in an article based on a voluminous study by one of the country's leading materials research groups. Comprehensive data will be given on properties, workability, and applications.

MORE EXOTIC stuff: Contributing Technical Editor Kurt Stehling will review the design and development problems of one of the most advanced rocket types, which has been the subject of a series of recent design studies.

WHAT KIND of detail design do the Russians come up with? A partial but revealing answer to this question will be given in an article analyzing one of the important subsystems of the Reds' Tu-104 jet transport.

CONTINUING its coverage of undersea weapon systems, SPACE/AERONAUTICS will present a Design Progress feature on one of the most important submarine detection devices.

coming soon

ELECTRONIC countermeasures will be the subject of SPACE/AERONAUTICS' next special report. In our coverage of this highly classified area, we will include staff-written articles on the scope and marketing potential of ECM and on the state of the art in design theory and practice, contributions by recognized experts on outstanding technical problems, and an exhaustive listing of companies working in ECM that will also give information on contract experience and capabilities.

DO YOU RUN into trouble when you try to visualize three-dimensional problems involving angles—in working on an inertial system, say, or a multi-gimbaled platform? Then watch for an upcoming series that presents in detail a proven, simplified method for visualizing and manipulating the relationships between the quantities involved in three dimensions.

What type of information do you want?

NO ONE has a mind so individual and specific in the matter of his technical reading diet as an engineer. At least that is the conclusion of our editor, who evaluates all the many requests for articles and kinds of information that come to him.

The trouble is, to fulfill each request we would have to publish a separate and different issue of SPACE/AERONAUTICS for each reader every month. Obviously, such a course isn't practical, however desirable it might be.

We have regularly been going through all your suggestions noted on reader certification notices returned to us, in letters, on reader service cards, and other media. While we cannot answer all such requests directly, we do evaluate them. Many of your suggestions have been made a part of the magazine. I think we are not boasting when we say no other technical magazine equals this one in being sensitive to its readers' information requirements. This is not to say that we think ourselves perfect in publishing all the information our readers want. It is because we are not perfect that our editor has devised the survey form below.

Since we cannot supply each engineer with just his specific requirement, the next best thing is to supply him with information in the areas of greatest technical importance in his work. These areas, properly treated, also will be of value to colleagues working in related areas, or in areas affected by the progress made in the one discussed.

Just as important as the technical area to be treated is the editorial approach to the subject. Some want survey-type articles with relatively little technical detail. Others want very detailed articles with lots of design data, tabular material on product or material characteristics and properties. Still others look for the theoretical article that has little or no application data.

Our special reports, such as the recent one on "Undersea Weapon Systems," have been more of the first type—the "broad brush" treatment—as they are intended to give the overall view. They call for a tremendous editorial effort. But how valuable are they to the majority of our readers?

To get a more organized expression of opinion from you on your information requirements, we invite you to use the survey form below.

William L. Maass
Publisher

Space/Aeronautics Reader Preference Survey

Randolph Hawthorne, Editor
Space/Aeronautics
205 East 42nd Street, New York 17, N. Y.

Listed here **in order of preference** are three areas in which I would like to see good technical articles:

(1) _____

(2) _____

(3) _____

My personal preference is that most articles be: **analytic survey types** with relatively little detail (. . .); **made up of detailed design data** on subjects of restricted scope (. . .); **primarily theoretical,** with little or no application data (. . .).

Comment: _____

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Yet with all this space-weight compression the Y-Series retains the built-in rugged dependability which has made Chatham the foremost manufacturer of airborne power conversion equipment. Use of Chatham's own silicon diodes and sturdy cast aluminum heat sinks is further indication that Chatham designed with reliability in mind. The new axial flow design featuring fan cooling offers maximum mounting flexibility but demands the very minimum in space requirements with considerable cost savings. Fan operation is guaranteed for 7500 hours with a minimum expected life of 10,000 hours at 71°C ambient.

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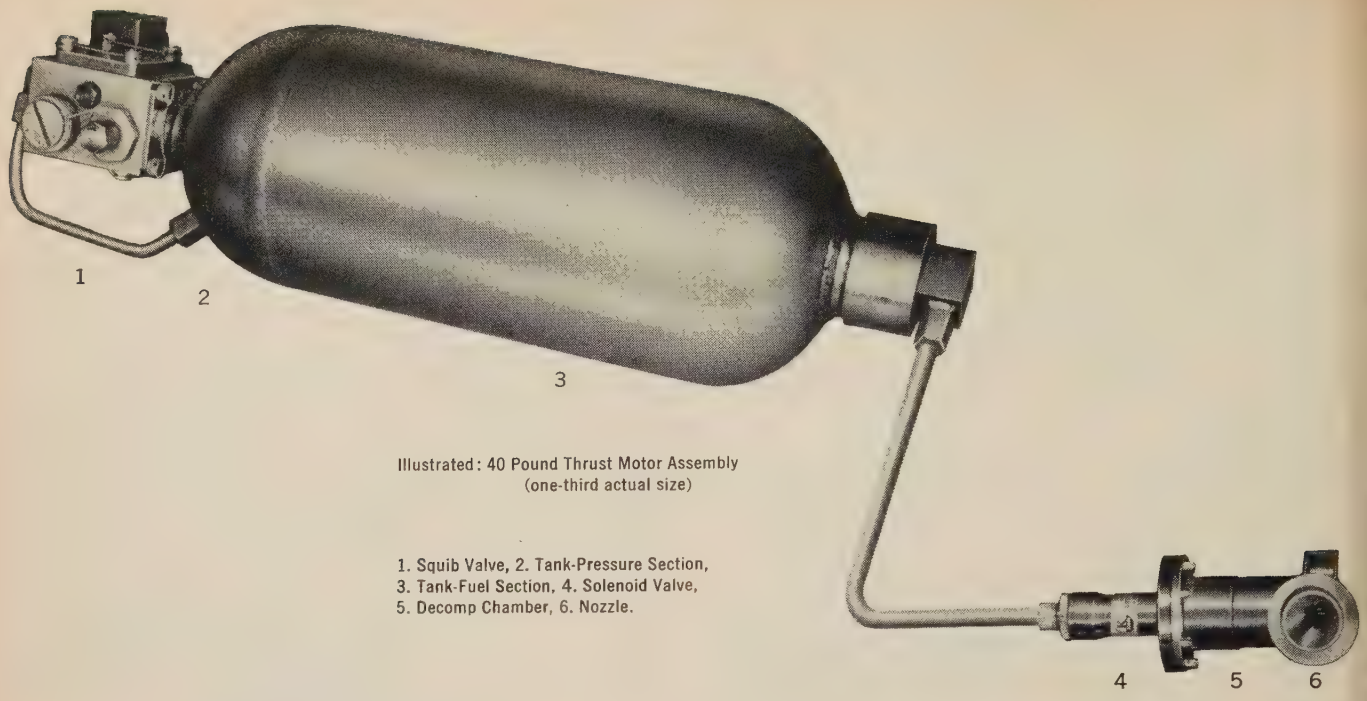

Illustrated: 40 Pound Thrust Motor Assembly
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1. Squib Valve, 2. Tank-Pressure Section,
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editorial

Government legal piracy should end

THE GOVERNMENT now is a legal pirate. It has made itself so by Congressional act and administrative practice.

If a company took specifications, drawings, and product samples from a competitor, and produced the competitor's product without paying for it, it would be morally and legally in the wrong. What is the difference if a government agency takes the specs and drawings and hands them to another company, from which it orders the product?

The practice is not confined to weapon systems. The end product of a defense plant is the property of the U.S. government. But hardware items procured by major contractors from third- and fourth-tier subcontractors belong to the firms that designed and produced them with their own money. Where hardware applies also to products not related to weapon systems, they cannot be the exclusive property of the government.

TWO YEARS AGO, the General Accounting Office told the Defense Department not to let potential patent infringements stop it from trying to get the lowest possible price for a product. If the patentee doesn't like it, he can go to court.

It is no wonder if defense agencies and primes must look on proprietary rights merely as nuisances in their day-to-day business, as charged by Robert R. Lent, chairman of the Patent & Proprietary Rights Committee of the Strategic Industries Association.

It might be pointed out also that the primes conceivably could be the victims of the same practice if it suited the government's whim.

PRINCIPLE ALONE is not involved. Is the practice, seemingly expedient, even smart in the long run?

Many firms throughout the country will not touch R&D contracts. Others won't accept orders from the primes or major subcontractors that require the slightest change in any of their basic products.

One firm told us it may get out of the electric connector business in missiles. It isn't only that the parts involved are more sophisticated than they are in aircraft, and that the finished product must be as cheap. It is because often, after the item is designed and developed, it is let to a smaller company—which doesn't have the original overhead—so that the prime can satisfy the General Accounting Office's insistence on the cheapest product.

We urge the Administration, which has tried to raise the moral tone of government in other ways, to end this practice. It isn't smart or moral.

Randolph Hawthorne, Editor

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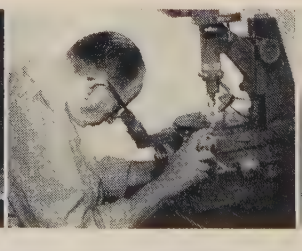
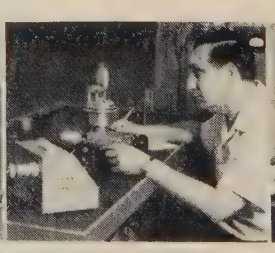
Bulova barometer sensitive to 0.001" Hg





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by Robert M. Loebelson, Associate Editor

What's in the budget for aerospace?

THE PRESIDENT'S budget estimate for the fiscal year beginning next July 1 contains no surprises. The budget indicates that the Defense Department will have expenditures totaling nearly $41 billion and will receive new obligational authority of $40.6 billion for the fiscal year.

A unique aspect of the 1961 defense budget is that the Navy will be buying more airplanes than the Air Force for the first time. Of the 1510 aircraft to be procured, 658 will go to the Navy, 633 to the Air Force, and 219 to the Army.

DOD's total of $13.6 billion in spending will include $6 billion for aircraft and $3.5 billion for missiles. The $13.1 billion in new money for procurement includes $4.8 billion for aircraft and $3.8 billion for missiles.

The Army will get $9.5 billion in new obligational authority under the President's budget request, the Navy $12 billion, and the Air Force $17.7 billion. The remaining $1.3 billion of the $40.6 billion allocated to DOD is assigned to the office of the Secretary of Defense.

This is how the individual services will use their procurement money for fiscal 1961:

USAF will continue to buy the B-52H, acquiring enough Stratofortresses to complete 14 wings. Other procurement funds will cover follow-on purchases of the B-58, F-105, and C-130. Two prototype B-70 aircraft due to be flight-tested in 1963 are also funded in the AF's procurement account, as is a new plane to modernize the MATS fleet.

The Navy will buy the A3J, F8U-2N, F4H, the GV-1 tanker-assault transport, and the S2F.

The Army's procurement funds will cover purchases of the Mohawk turboprop, the Caribou twin-engine transport, the Iroquois utility helicopter, and the first production quantities of the Chinook helicopter.

In the missile area, funding will cover purchases of the Atlas, Titan, Minuteman, and Polaris strategic missiles. There are no funds for further procurement of either the Thor or the Jupiter. Hound Dog and Quail missiles for use aboard the B-52 will also be procured.

In the air defense area, 1961 will see the final funding for the Bomarc and the Nike-Hercules. Procurement of the Talos, Terrier, and Tartar will continue.

In the air-to-air missile field, procurement will continue on the Sparrow for the Navy (including the Marines), the Falcon for USAF, and the Sidewinder for the Navy and USAF.

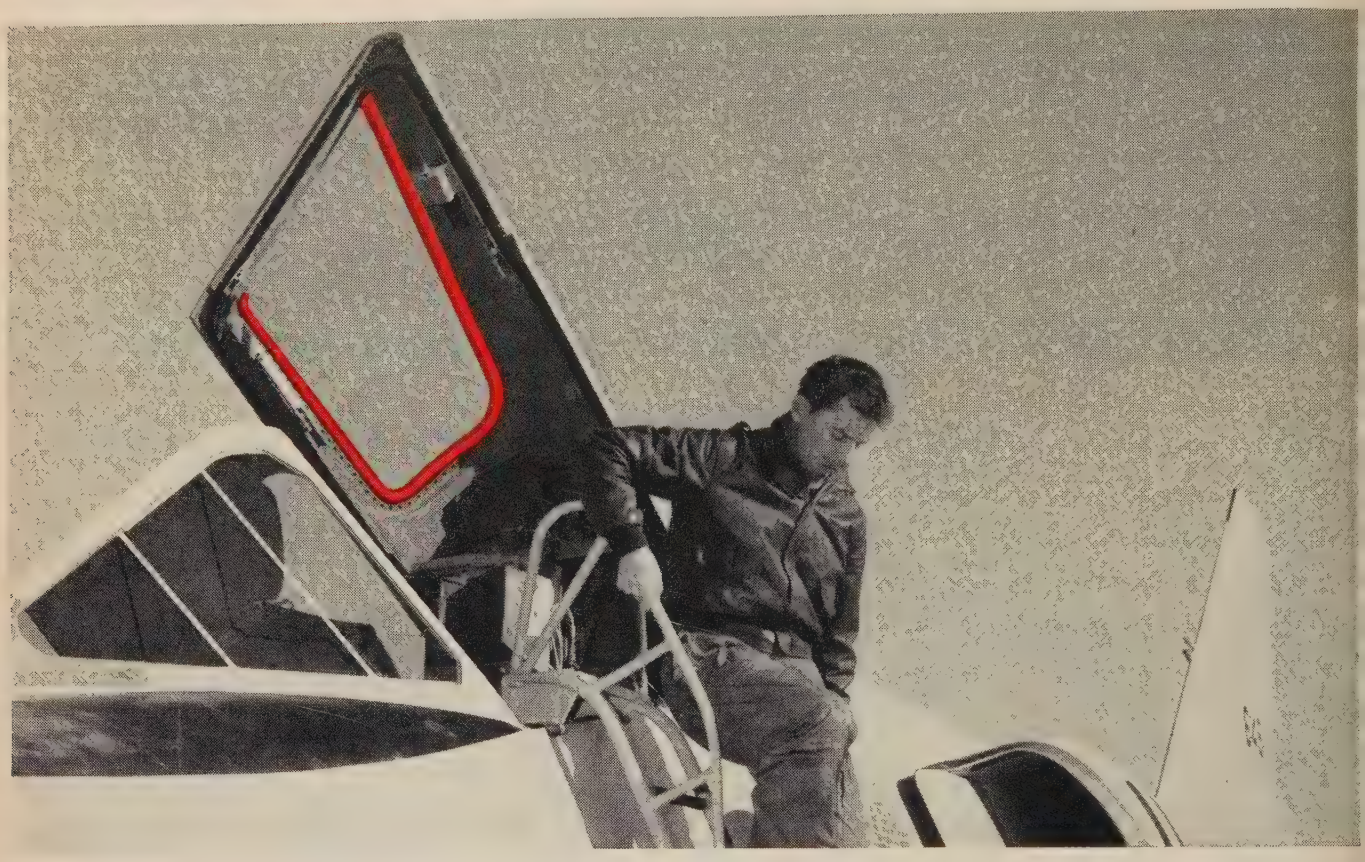
Ground troops will be supported by a wide variety of missiles to be procured in fiscal 1961. Included are the Bullpup air-to-surface missile, the 800-mile range tactical Pershing, and close-support missiles: Little John, an improved Honest John, Lacrosse, Sergeant, and the Mace. Other Army missiles scheduled for purchase in 1961 are the Hawk and Redeye air-defense missiles, an improved guided anti-tank missile, and a sizable quantity of Davy Crocketts (which are actually man-carried rockets with nuclear warheads).

For research, the three services and DOD's Advanced Research Projects Agency are asking $3.9 billion in new money and expect to spend a total of $3.95 billion (for research, development, test, and evaluation). Included in the latter figure are $446 million for aircraft R&D, $1.5 billion for missile R&D, and $318 million for space R&D.

The aircraft account in R&D covers new Army mobility and recon types, Navy long range search, anti-sub, and air-defense types, and STOL and VTOL aircraft for USAF. It also covers continuing work on the X-15, the Dyna-Soar, and the nuclear-propelled aircraft.

more on page 21

Seals With ± Zero Tolerance



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*SHOWN: F-106 DELTA DART.

TYPICAL PROPERTIES OF SILASTIC RTV SYSTEMS

After Vulcanizing (24 hours at 77 F)	*Fluid Grade*	*Caulking and Putty Grade*
Hardness, Shore A	30 to 65	20 to 55
Tensile Strength, psi	250 to 850	225 to 450
Elongation, percent	100 to 250	120 to 400
Brittle Point, degrees F	—100	—178 to —100
Shrink, linear, percent		
after 3 days* at 77 F	0.6	—
after 6 days* at 77 F	0.8	1.2 to 1.6
after 14 days* at 77 F	1.1	—
Water Absorption, percent after 70 hours immersion at 212 F	1.0	1.0
Working Time	10 min. to 3 hr	2 to 5 hr

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Missile research programs include the Zeus anti-missile missile, the Army's Redeye, Mauler, Hawk, Sergeant, and Pershing, the Subroc and an advanced Polaris for the Navy, and the Air Force's Skybolt air-launched ballistic missile.

The President's budget message concedes that R&D funding for 1961 will be down from the current fiscal year. He points out that for 1961 total direct obligations will be $5.3 billion (including $3.95 billion in the R&D account and $1.3 billion in development and test items in the procurement account), as against $5.8 billion for fiscal 1960. The budget message explains this drop by declaring that "many costly development programs are progressing into the stage of production for service use and certain others have been curtailed, transferred, or terminated." Examples of projects in transition are the Army's Mohawk aircraft and Sergeant missile, the Navy's Terrier and Tartar missiles, and the USAF's Atlas. Among the curtailed programs are the aircraft and command control systems for the B-70, the F-108, and an improved version of the Lacrosse.

Breakdown of the R&D money by services shows that the Army will obligate $1 billion, the Navy $1.2 billion, the Air Force $1.3 billion, and ARPA $215 million. An additional $150 million is assigned to the Secretary of Defense as an emergency fund.

The budget message indicates that only the Army will end its 1961 fiscal year with more aircraft on hand than it will have on June 30, 1960. The Army will operate 5791 aircraft on June 30, 1961, including 2840 helicopters and 2951 fixed wing airplanes. The Army production for June 30, 1960, shows a total of 5663 aircraft, including 2714 helicopters and 2949 fixed wing airplanes. The Navy's active inventory will drop from 8657 on June 30, 1960, to 8348 on June 30, 1961. Over the same period, USAF active aircraft will decrease from 19,513 to 18,885.

The number of USAF combat wings will decline from 96 to 91—SAC will lose two wings of its 40 and ADC three of its 23. The number of TAC wings will remain at 33.

The President's budget asks $802 million in new obligational authority for NASA for 1961. But this sum does not really represent any substantial increase over the $500 million voted for NASA for the current fiscal year.

Part of the increase is accounted for by the Saturn project ($140 million), which was transferred to NASA from ARPA. The 1961 estimates also reflect the transfer of the ABMA operation at Huntsville, Ala. About $57 million of the Saturn booster program is for work to be performed at Huntsville; another $35 million will be used at Huntsville for other space projects.

The $802 million request includes $129 million for aeronautical and space research, $660 million for space flight development and operations, and $12.5 million for program direction. Not all of the requested new money will be spent, however. Only $120 million will be used for aeronautical and space research, while $498 million will be spent for space flight development and operations.

In 1961, NASA's aeronautics and space research will be focused primarily on problems of manned and unmanned space vehicles. Only a relatively small effort will be devoted to problems peculiar to aircraft and missiles. Among the areas to be studied are the heating problems, vibration and structural integrity of space vehicles, chemical rocket systems, and nuclear and electric rocket systems for space vehicles.

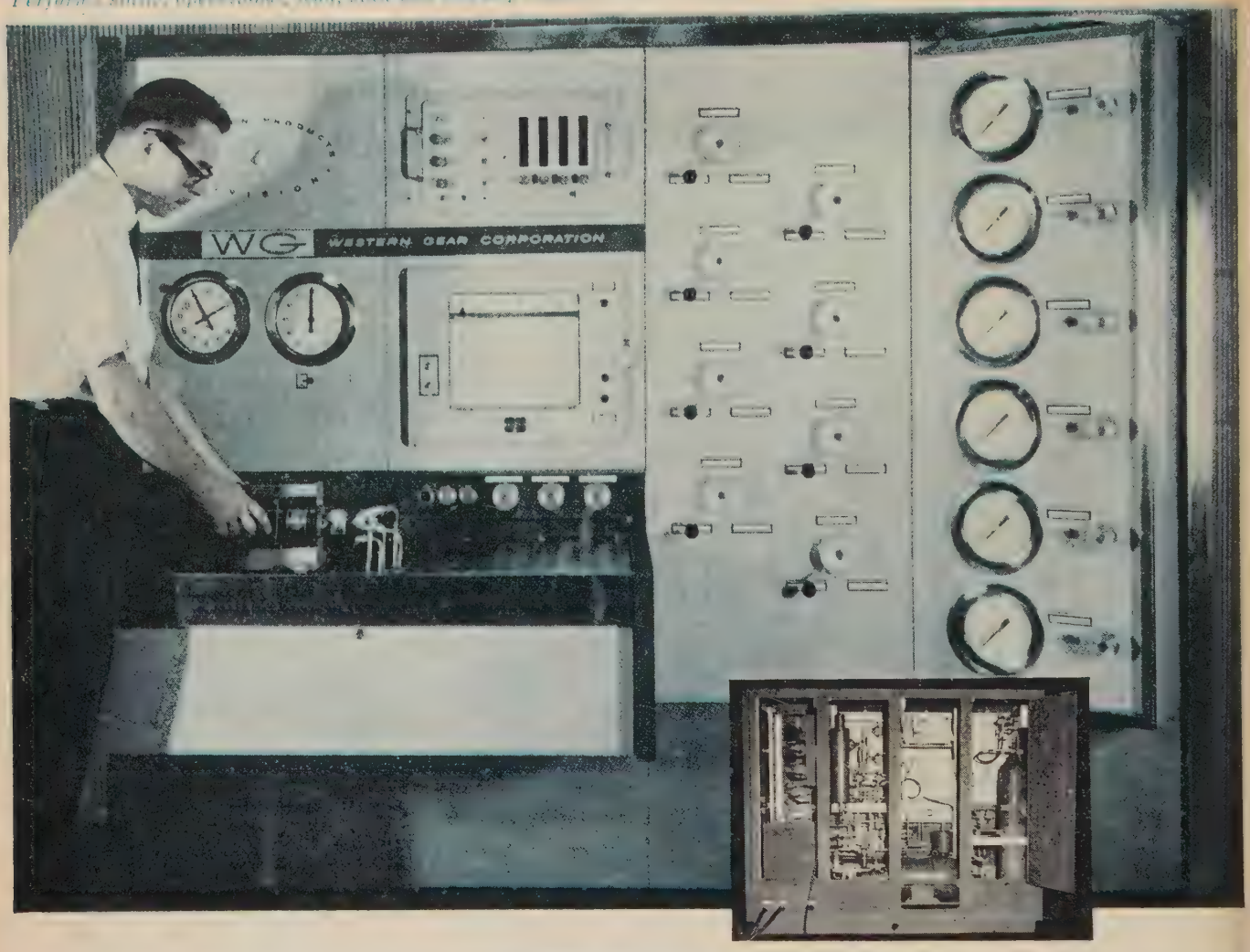
NASA expects to devote much of its fiscal 1961 work to problems of space vehicle guidance and control and the special operating problems of the space environment.

In the aeronautical field, applied work will be limited to very high speed aircraft now under development for the military services, to VTOL and STOL research, and to continued study of nuclear aircraft propulsion. In the space flight development and operations area, primary emphasis will be placed on Project Mercury and on the development of very high thrust boosters and other space vehicle components.

Under present plans, manned space flights for Project Mercury may be tried in 1961. NASA believes a space vehicle using very high thrust boosters is still several years away, but expects substantial progress through testing of the clustered Saturn booster. With fiscal 1961 money, the development of the very high thrust single-chamber engine and of engines for upper stages of space vehicles will be continued. Under Project Centaur, a space vehicle using an upper stage featuring high energy fuels is being developed. It should be ready for testing in 1961.

One interesting aspect of the funding for Saturn in 1961 is the tremendous jump it represents. In fiscal 1959, DOD allocated $27 million to Saturn; another $77 million was appropriated for the current fiscal year. The $140 million NASA will spend on the program in 1961 should go far toward speeding up the development of this clustered booster.

Three station test stand console designed by Western Gear for field servicing of Convair F-106 Vari-Duct Drive unit. Fourteen individual performance tests guarantee reliability. High pressure hydraulic test at 4500 psi, low pressure at 300 psi, pneumatic emergency test at 3000 psi. Features built in include safety precautions to prevent unit damage during test and calibration. Perform static, operational, load, stall and running tests, includes counter and recorder. Stainless steel piping throughout.



True craftsmanship shown in this sturdy yet simplified design of a complicated test console, designed, developed and built by Western Gear.

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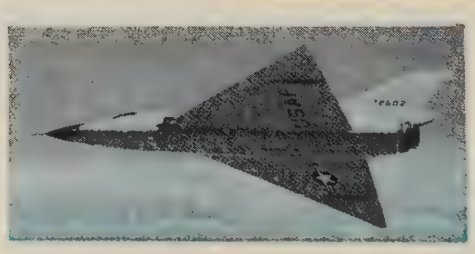

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BMEWS and Samos are headed for money trouble

WHILE the national debate over production orders for the Nike-Zeus anti-missile goes on, two related programs are also headed for budgetary trouble. The Ballistic Missile Early Warning System (BMEWS) is being delayed on two counts: a rash of strikes at the Clear, Alaska, site, and a Pentagon decision to hold off the purchase of some important target-identification equipment.

The Pentagon had hoped to have the Alaskan site—along with another at Thule, Greenland, and a third in northern England—operational by July '61. The base now will not be ready to detect Soviet ICBM launchings until January '62 at the earliest.

THE SECOND program in danger of delay is the Lockheed Samos recon satellite, the programed successor of BMEWS. Although some $300 million will have been invested in Samos by the time the '60 fiscal year ends in June, the funds allocated for fiscal '61 tend to delay full-scale operation of the satellite.

How much delay there will be is a matter of dispute. Some high-ranking USAF sources say the Samos program is not being pushed fast enough to meet national requirements. Others believe not only that additional funds would not speed the program but also that the present schedule for the development of key Samos components is optimistic.

Although a Samos test model is due to be fired in the next few months, present programs do not call for satellites in actual north-south polar orbits for several years. The optimistic view of some USAF officials is that more money in the Samos program (which in the past has also gone by the names of Sentry, Big Brother, Pied Piper, and WS-117L) would put U.S. cameras over Russian territory in less than two years.

Rapid tax write-off over for the defense industries

DEFENSE and defense-supported manufacturers now can no longer amortize the cost of new plants and equipment over five years for tax purposes. The rapid-tax-writeoff program, started in '50 to encourage the erection of defense facilities and the acquisition of modern production equipment, permitted producers to shorten the normal 20-25-year amortization period.

All told, the agencies administering the program granted tax benefits for more than 22,300 projects costing a total of $39.6 billion. More than $23.3 billion was approved for fast writeoff. Aerospace firms accounted for a majority of the more than 22,000 approvals.

THE PROGRAM drew frequent criticism in Congress. One Congressional committee referred to accelerated amortization as "the biggest bonanza that ever came down the pike." Nevertheless, a modified version of accelerated writeoff probably will have to be passed by Congress by adjournment time in July.

AIA believes industry sales will remain the same despite drop in planes

DESPITE the continuing decline in manned aircraft production for the military services, the Aerospace Industries Association expects industry sales in '60 to be "well over $10 billion." AIA president Orval R. Cook believes the '58 and '59 level of $11 billion will be approached thanks to climbing missile and space vehicle sales, increased deliveries of jet and turboprop transports, and the expanding market for business and utility planes.

Cook indicates, however, that industry earnings will continue to drop. The top 12 companies in the aerospace industry have seen their net profits decrease steadily from 3.7 to two per cent of sales between '54 and '58. Indications are that the profits for '59 will be just over one per cent on sales.

REASONS for the reduction, according to Cook, include contract cancellations and stretchouts, economic limitations, and a greater proportion of R&D contracts. AIA's president predicts that "the increasing trend toward R&D contracts will continue to adversely affect the rate of earnings." He adds that the industry's billion-dollar investment in R&D programs and facilities during the first 10 years after World War II will be doubled by '61.

•

AMONG the industry's '59 accomplishments were the delivery of 245 commercial turbine transports and the sale of 7100 lightplanes worth $170 million. Military aircraft output slid from 3700 units in '58 to 2400 in '59, while missile spending rose to $3.5 billion last year. Including heli-

more on next page

copters, commercial aircraft production last year came to 8100 units, and sales of commercial planes, engines, and parts ran to $1.7 billion.

The industry's backlog of orders has been declining, too. By the end of '59, it had fallen under the $12 billion mark, as against $13.2 billion in unfilled orders at the end of '58. More than 75 per cent of the backlog drop was accounted for by the fall-off of military orders.

THE ELECTRONICS industry, on the other hand, foresees a "fairly substantial" increase in military business for '60. David R. Hull, president of the Electronic Industries Association, estimates that electronics now accounts for one-third of all defense procurements and will rise this year.

He also points out that electronics in non-military space applications will also shoot up. Hull says electronics hardware for civil (NASA) space vehicles approached $100 million last year and will increase at least eightfold over the next decade.

Gen. Kuter urges production of Zeus, says NORAD needs such a weapon

THE ARMY received support for the production of the Zeus anti-missile missile from an unexpected source—USAF's Gen. Laurence S. Kuter. Nevertheless there seems little likelihood that DOD will authorize the start of Zeus production this year.

Kuter, reflecting a staff position taken by top officials of the North American Air Defense Command (NORAD) at Colorado Springs, Colo., told the Joint Chiefs of Staff that NORAD urgently needs an anti-missile missile. In his position paper, he pointed out that, while Zeus is not necessarily the only such missile, it is the one considered closest to development by DOD.

ARMY SECRETARY Wilber Brucker has been fighting to get the $137 million voted last year by Congress for Zeus pre-production items unfrozen. He's had no luck so far. Douglas and Western Electric, the prime contractors on Zeus, are not optimistic that the funds will be released by DOD. The new budget provides additional funds to carry on Zeus R&D—but no production money.

The Army is taking the position that, if DOD wants Zeus production started, the cash for it should not come out of the Army's regular budget but that DOD should provide separate funds.

NASA last year did about 40 per cent of all its work internally (counting Huntsville and the Jet Propulsion Lab). It is not planning to increase this percentage—industry will do the rest.

The assignment of Huntsville to NASA will cause a change in organizational structure. The Alabama facility will handle space vehicles and propulsion; the Goddard Space Center near Washington, D. C., will be concerned with orbital space probes; and JPL will be responsible for deep space probes.

NASA IS PLANNING to request almost $30 million in supplemental funds for fiscal '60 to speed up the Mercury program and other projects.

Change in its patent policy is pushed by NASA

NASA IS TRYING to give its industrial contractors a break on patents. It is asking Congress to make its patent rules similar to those of DOD and the National Science Foundation. Instead of requiring the NASA head to take title to an invention unless he chooses to issue a waiver, the proposed amendment would emphasize his right to waive the claim.

DOD, AIA, the Patent Office, and other groups are supporting the proposal. Under DOD procurement regulations, the Government takes a non-exclusive, royalty-free license and in most cases grants defense contractors patent rights.

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DEFENSE CONTRACTS generally are becoming a political issue. The Senate Small Business Monopoly Subcommittee, under Democrat Russell Long of Louisiana, is trying to decide whether DOD's contracting policy creates a tendency toward monopoly and/or stifles the dissemination of data. Long has gone so far as to charge that DOD's patent program "has the result of erecting walls between teams of American scientists."

USAF WILL INVEST its own cash in new plants "only in extreme cases." With that warning, Maj. Gen. Ben I. Funk, who left as head of the AMC Ballistic Missile Center last month to command the San Bernardino (Calif.) Air Matériel Area, has told major contractors and subs to use their own capital. Contractor-owned facilities will better a company's chances of getting a new contract in the future.

Funk also indicates the Air Force will try to write as many incentive contracts as possible from

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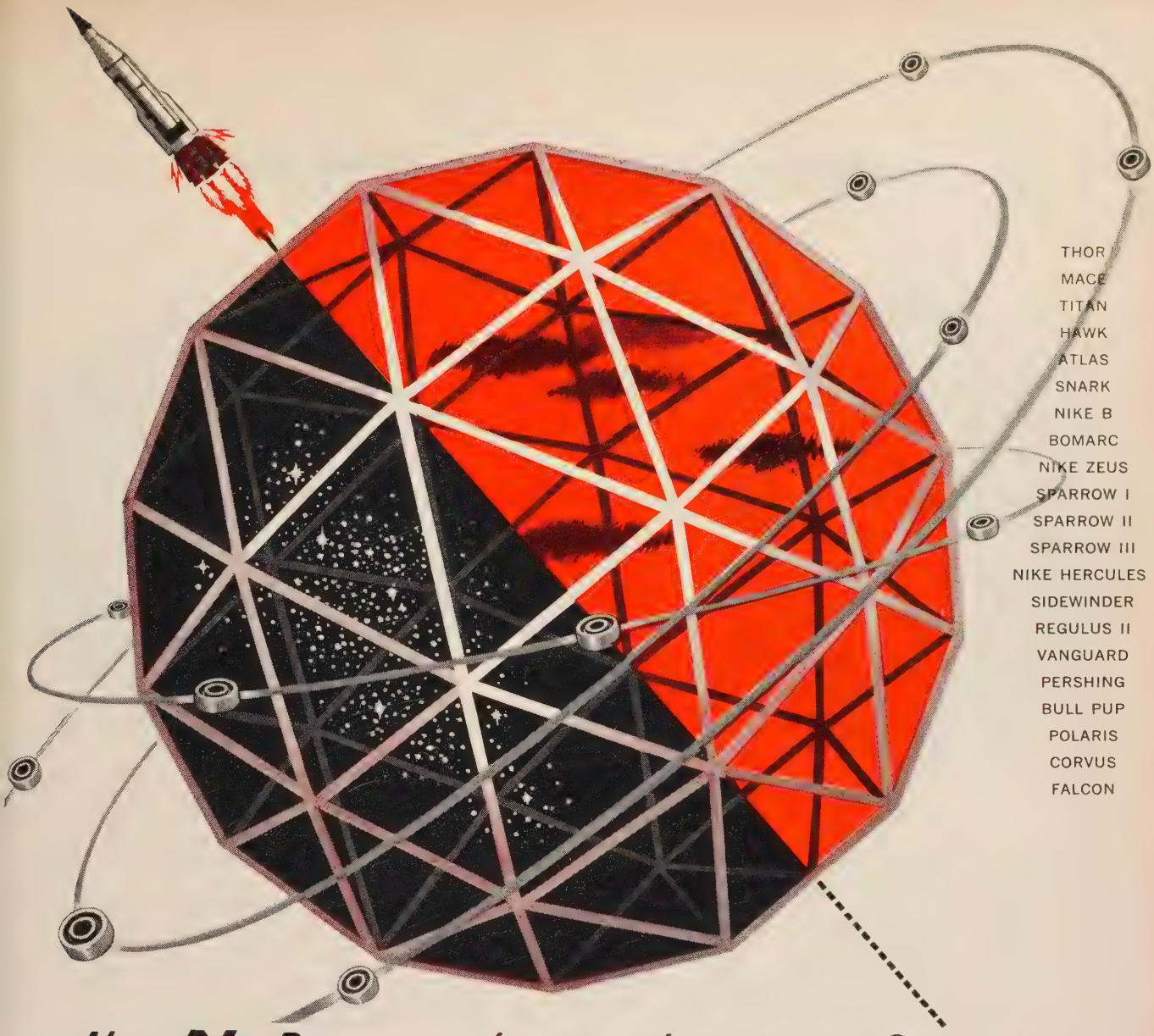

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now on, with less reliance on the cost-plus-fixed-fee (CPFF) type. AF does not expect contractors to operate at a financial risk or at a loss, he says. But firms should try to work out realistic pricing patterns that will be in the best interest of the government.

Even in R&D contracts, Funk declares, the USAF prefers incentives. "While we realize that, in most R&D, a CPFF proposal might be the best acceptable offer, we are encouraging the cost-plus-incentive-fee approach whenever and wherever possible."

FRANCE'S Sud Aviation Caravelle medium-range jetliner may be built by a U.S. firm. Both Douglas and Convair are talking to Sud about licenses. General Electric meanwhile ordered a Caravelle and plans to fit it with aft-fan CJ-805 jet engines for tests.

India may build a turboprop designed by Lockheed to replace the DC-3

INDIA'S GOVERNMENT is negotiating with Lockheed for rights to a 42-passenger, turboprop DC-3 replacement. Under the projected agreement, India would put up a $5.2 million plant to build the Lockheed plane, which will not be in production for three to four years. Lockheed would provide technical aid in building the plant and the Dart-powered plane.

•

LOCKHEED acquired an "important" interest in Aeronautica Macchi and will license the Italian firm to produce a six-place, all-metal, high-wing lightplane. A prototype has been flying at Marietta, Ga., since September, and a similar license has been granted Lockheed's Mexican subsidiary. The first Macchi unit is due this summer.

REPUBLIC EXPECTS a doubling of USAF orders for its F-105. About 200 planes for TAC. An additional 200 "D" models will be procured with fiscal '61 money.

NAVY awarded Chance Vought a $58 million contract for the F8U-2N, gave North American $73 million in new orders for the A3J, and provided Grumman $26.3 million in follow-on orders for the WF-2.

USAF is still planning to buy 70 B-52Hs with '60 money but has cut back the 96 KC-135 jet tankers ordered this year to 66. The 32 B-58s originally ordered for '60 will be reduced to 20.

USAF placed a new $46 million order with Northrop for 50 T-38 supersonic trainers.

ARMY is planning to buy 24 de Havilland Caribou cargo planes in fiscal '61. The entire Caribou program calls for more than 500 planes.

USAF is planning to procure a new tactical fighter superior to the F-105 and will soon ask companies to submit designs. One of the planes USAF is studying for this purpose is a modification of the Navy's North American A3J.

BELL HELICOPTER received $26 million in Army contracts for the HU-1 shaft-turbine copter.

MARTIN received a $10.5 million Army award for continued R&D work on the 800-mile solid propellant Pershing tactical missile. It also got $22.6 million in Bullpup contracts from the Navy. Both awards went to the Orlando Division.

NAA'S MISSILE DIVISION at Downey, Calif., delivered the first production model GAM-77 Hound Dog for use aboard the B-52.

All Titan activities now are under one hat at Martin

MARTIN, whose Titan ICBM has been having its troubles, put all Titan activities in one division headed by chairman George M. Bunker. He will use Denver as a headquarters to supervise the Denver and Cape Canaveral operations as well as the Activation Division, which is concerned with Titan bases.

•

P&WA OFFICIALS are optimistic about the prospects of the XLR-115, the first liquid hydrogen rocket engine. In several successful firings at 15,000-lb rated thrust, it produced a specific impulse 30 per cent greater than that of current kerosene-fueled rockets.

MARINE CORPS is evaluating the West German wire-guided Cobra anti-tank missile. Daystrom, which holds U.S. rights, has sold the Marines 100 models for evaluation.

AUTONETICS received $115 million in AF contracts for inertial guidance and flight control systems for the Boeing Minuteman ICBM. The contracts also cover GSE.

SCIENTISTS AND ENGINEERS: There are two sides to the STL coin...

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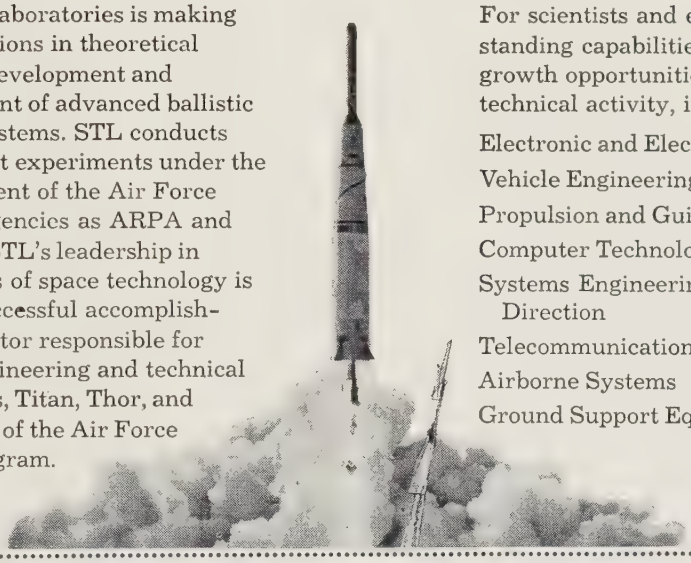

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industry viewpoint

by **Robert M. Loebelson,** Associate Editor

We must have central decision-making!

JAMES R. DEMPSEY, manager, Convair-Astronautics.

THE ADMINISTRATION is determined to keep defense spending at a constant level. The result has been cutbacks in several programs considered vital by the military services. Nevertheless, many officials in the White House and the Pentagon are hopeful the U.S. will be able to deter Russia.

One of the leading men of the aerospace industry is not as optimistic. Says James R. Dempsey, manager of Convair-Astronautics, "I have less confidence that we will somehow muddle through than I have ever had before."

Dempsey, a West Pointer and an Air Force colonel before joining Convair in 1953, concedes that defense costs are skyrocketing. But then he goes on to point out that we are not taking the proper approach to decision-making.

The Convair executive, who is responsible for production of all Atlas ICBMs and space boosters, contends the U.S. has the financial resources to achieve a satisfactory defense position. But before we can achieve this position, "someone must decide what should be done," he declares. "Unfortunately, there is no system for deciding what we as a nation should do. The civilian chiefs in the Pentagon don't have the background for a proper evaluation when they get split decisions from the Joint Chiefs of Staff."

Dempsey insists that a single military service and a single decision-making authority are both necessary for our national survival. "Somehow or other, we must eliminate the situation in which an individual's future depends on whether he does or doesn't get a new weapon system for his service. Under the present setup new weapon systems are decided on without full discussion of their usefulness to the nation as a whole."

Dempsey foresees fewer duplicate or backup programs in the future. "The ratio of development cost to production cost has been increasing steadily over the last few years," he says. "It wasn't too long ago that the cost of developing a new system was relatively small, and the country could afford to sponsor parallel developments. It worked out that total program costs would be only about 10 percent higher. Now the price of developing a new system is almost equal to that of making the system operational. Obviously we won't be able to afford backups in the future."

Despite these views, Dempsey is convinced that research on both liquid and solid propellant rockets should be continued. "Where large amounts of thrust are desired for high total energies, solids will never be as useful as liquids," he believes. Specific impulses and flexibility are the prime factors favoring liquids.

On the other hand, Dempsey is equally certain that solids will be used for missions requiring low thrust levels. "Large solid boosters will never be used, because there is a limitation on the transportability of solids. The Minuteman first stage is just about the optimum size for solid rockets, and it will be equally usable for manned or unmanned space missions," he declares.

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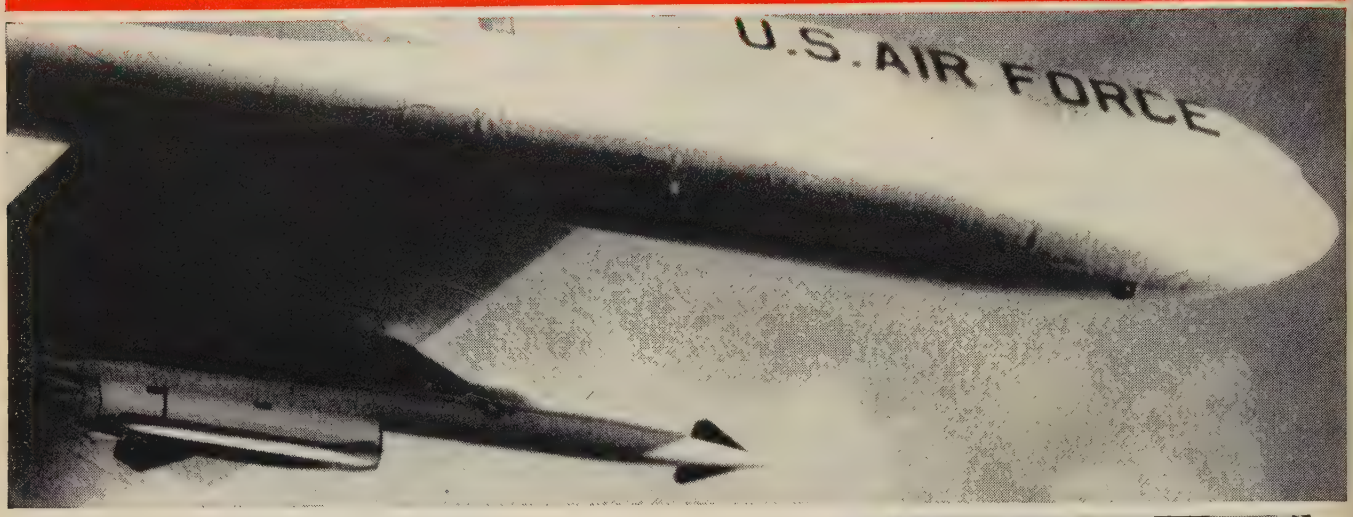
Aeroquip Quick-Disconnect Couplings and Hose Lines of Teflon Speed 'Hound Dog' Handling



Hound Dog, the Air Force's new air-to-surface nuclear-armed missile, lengthens and strengthens the retaliatory arm of the Strategic Air Command. Designed and manufactured by North American's Missile Division, the GAM—77 Hound Dog is equipped with Aeroquip Hose Lines of Teflon and Quick Disconnect Couplings. Used on its internal hydraulic system and on ground service checkout equipment, these Aeroquip products speed handling and checkout of system components.

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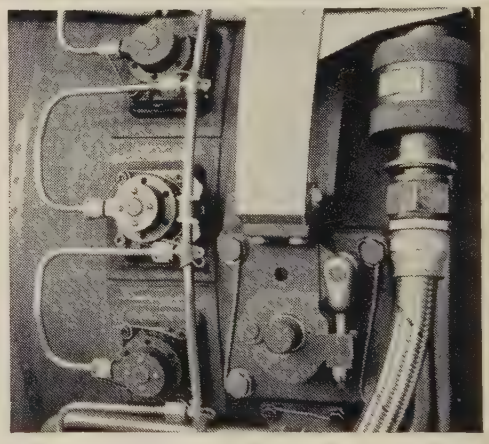

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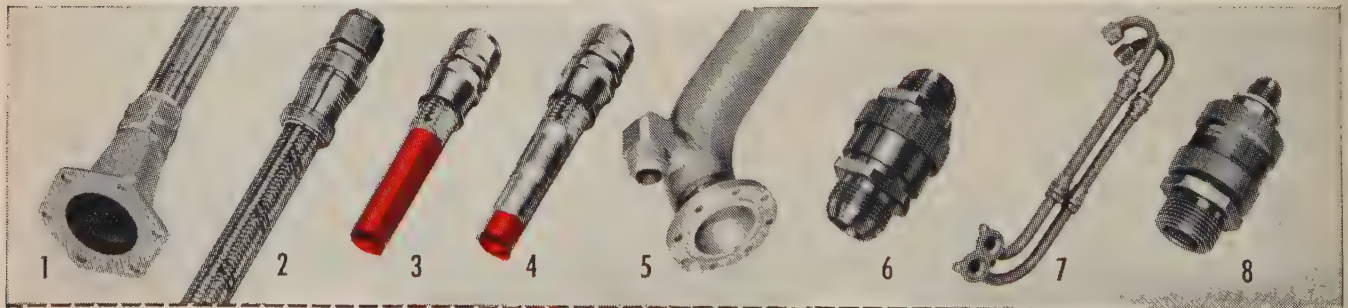

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Mars expedition in sixties is said to be feasible

MANNED MARTIAN expedition could be successfully mounted by U.S. within the next decade, Douglas engineers M. W. Hunter, E. B. Konecci, and R. F. Trapp state. Their recent studies were based on a two-stage, 734,000-lb, nuclear-powered vehicle. The return trip would depend on placing three tankers in orbit around Mars, each yielding 88,000 lb of fuel. The manned ship would be placed in orbit around Mars, and a small, maneuverable chemical vehicle used for ferrying crew members to the planet's surface.

The spacecraft's payload would be 55,000 lb, including a three-man crew, life support material, shielding, equipment, structure, and the fueled chemical vehicle. Sustenance material for the crew, including food and water, is estimated at 15 lb per man per day, for a total of 19,000 lb for the 14-month round trip. The Douglas researchers state the total radiation exposure for the mission would be less than the permissible AEC dose for one year.

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JOINT U.S.-CANADIAN space experiment came off when a four-stage sounding rocket was launched from Wallops Island, Va., recently. One of the aims of the test was to measure intensity of galactic noise with equipment provided by Canada's Defense Research Telecommunications Establishment. The second objective was to determine the performance in a vacuum of the X248 engine, slated to form Delta's third stage.

The 48-ft Javelin launch vehicle had a takeoff weight of about 7000 lb. An Honest John and two Nikes were the first three stages, and an X248 was the fourth. The 48-lb payload contained a three-megacycle radio receiver to telemeter galactic signals to earth from altitudes above 450 miles. The vehicle reached an altitude of about 560 miles.

Nuclear power for low-level attack missile?

ITS NUCLEAR MISSILE feasibility studies will be completed by March or April, Grumman reports. The company-financed program is run under a dollar-a-year contract with BuWeps and gives Grumman access to classified data on relevant nuclear studies. Areas covered include heat transfer properties, reactor analysis, reactor shielding, radiation effects on materials, and materials that could be used to make reactors more compact.

A possible vehicle, Grumman engineers state, is a nuclear-powered low-level attack missile that could avoid early radar detection. Chemically fueled missiles, they note, require too much fuel to perform such a mission. As part of the program, Walter Scott, chief of preliminary design, says, his group has been particularly interested in applying high intermediate-type reactors to nuclear ramjets.

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STEREO-VISION X-RAY has been developed by Convair Astronautics for better inspection of missile components before launch. The method involves taking two X-ray negatives of a part at slightly different angles with standard X-ray equipment. The films are then studied in two modified X-ray film viewers and a mirror system in which two mirrors are set at 45 deg to each other. An observer places his head against the point of the V, so that each eye looks into a different mirror. He then adjusts the mirrors so the negatives are superimposed in the mirror reflectors. The improved depth perception, engineers report, makes it possible to spot minor flaws in internal components that might not be found with conventional X-ray.

First CT58-100, said to be first certified copter turbine, is shipped out

GENERAL ELECTRIC's first CT58-100 commercial turboshaft copter engine, said to be the first U.S. gas turbine certified by FAA for commercial copter service, was shipped to Sikorsky. The engine, a commercial version of the Navy's T58-6, is designed to deliver 1050 shp with an SFC of 0.64 lb/hp-hr. At a weight of 280 lb, its power-weight ratio is 3.75. The engine is scheduled for use in Sikorsky's S-61 and S-62 and in the Vertol 107.

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RELATIVELY LARGE prototype sheet and sandwich structures of molybdenum are being prepared by Astrometals' Finn Aeronautical Div., of Hawthorne, N.J. Key to its success, Finn states, is the development of methods that yield molybdenum weldments with good ductility and strength and freedom from cracking. According to company engineers, the size of these structures—which include leading edges of wing and tail

more on next page

surfaces for spacecraft—is restricted only by the practical limitations of available 0.5 Timolybdenum sheet.

Finn's work is being done for NASA. The company reports it also has NASA contracts for the study of columbium, tantalum, tungsten, and beryllium fabrication methods.

NEW RECORDING medium that may rival both magnetic tape and photographic film was announced by GE's Research Lab. The medium is a thermoplastic film on which both images and sequential data can be imprinted electronically and recorded by a heating and cooling process. Data can be erased (by heating the film to around 350 deg C), and the film can be used again.

According to GE, thermoplastic recording (TPR) combines the processing speed and versatility of magnetic tape with the storage capability of photo—and offers new advantages. In its developmental form, it can already concentrate 100 times as much information in a given space as can magnetic tape, claims GE. The company has gotten $40x10^6$ bits per square inch in the lab.

ANOTHER IMPORTANT feature of TPR is wide bandwidth—lab models are claimed capable of handling 50-mc data. GE engineers told SPACE/AERONAUTICS that TPR will ultimately record phenomena occurring at rates higher than 500 mc.

Color as well as black and white images can be gotten with TPR. Samples show good definition in both cases. Recording is done by electronic scanning; readout is by opto-electronic scanning.

Lack of properly scaled upper stages is holding up space progress

FIRST-STAGE BOOSTERS aren't primarily what's holding back our space program, NASA's Dr. Homer J. Stewart declared in a recent speech. For Explorer VI, Stewart noted, ratio of takeoff to payload weight is about 750. A properly proportioned three-stage vehicle at the present state of the art, he said, should have a ratio of 40-50. Similarly, Pioneer IV had a ratio of 8000, but really should have had a ratio of only 150-200.

Stewart drew the conclusion that today we are primarily limited because "we do not have the appropriately scaled upper-stage rockets to exploit efficiently our large military booster rockets as . . . launching vehicles." The upper-stage rockets of Agena and Centaur, he said, should correct this situation: "The high energy propellant . . . . used in Centaur is expected to produce a payload capacity in orbit corresponding to a ratio of about 30:1."

IN THE LONG RUN, of course, the development of 1,500,000-lb-thrust boosters becomes inevitable, Stewart said. But the successful use of these monsters, too, depends on development of efficient upper-stage rockets.

"Quantitative metallography" said to provide more dependable measurements

NEW APPROACH to metallurgy, called "quantitative metallography," can provide important advances in alloy development, Dr. E. E. Underwood, of Battelle Memorial Institute, states. It expresses in numbers such features of metallic microstructure as grain size, volume percentage of alloy constituents, and mean particle spacing. Basic equations have been developed for use with data obtained with the Hurlbut mechanical counting device, for instance.

The new methods, states Underwood, have provided more dependable measurements than were previously available—and has done so at a saving in time. They have also proved useful for finding the volume fractions in polyphase mixtures and for measuring the particle spacings of dispersed phases. Above all, they have provided new data on the relationship of particle dispersion and alloy strength, which may lead to the development of better high temperature alloys.

TWO IMPROVED DYNAMIC methods for finding the thermoelastic properties of metals and alloys have been devised by the Bureau of Standards. They are expected to pave the way for development of better high temperature spring materials for powerplants.

The "pendulum method" uses an oven, a photoelectric cell and lamp, a timer, a counter, and an electronic temperature recorder. A frame about the oven supports a three-foot-long, 0.5-in.-diameter steel rod extending down through a hole in the oven top into the heat chamber. A wire specimen is suspended between a chuck on this rod and one on the oven base. A small amount of twist is applied to the top of the rod, causing the

more on page 34

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DOUGLAS SELECTS BENDIX BRAKES FOR THE DC-8

It is fitting that the luxurious Douglas DC-8, one of the world's most advanced jetliners, should be equipped with Bendix, world's most advanced brakes. For these brakes, products of the most experienced manufacturer, perfectly match exacting jetliner requirements for smooth, sure ground control from touchdown to ramp. Besides being preferred for civilian jets, "Brakes by Bendix" are first choice on the fastest military jets.

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pendulum to oscillate about the specimen axis. The photoelectric cell and lamp then actuate the counter and timer to measure the oscillations. The resonant frequency thus derived for the specimen and the dimensions and masses of the pendulum are then used to compute the shear modulus.

THE "SONIC-VIBRATION method" involves the suspension of a six-inch prismatic bar specimen from an electromagnetic driver by two asbestos strings in a furnace that operates at up to 1000 deg F. The driver and a variable audio oscillator excite the bar to its resonant frequency. Vibrations are detected by a crystal pickup and shown as an expanded wave on a cathode-ray oscilloscope. The oscillator frequency is adjusted to the specimen frequency, and the adjusted frequency is measured with an electronic events-per-unit-time counter and then used to compute Young's modulus.

With rectangular prismatic bars, the prisms can be vibrated either in tension or torsion, so both Young's modulus and the shear modulus can be found.

Thermographic check of honeycomb structure

NEW NON-DESTRUCTIVE test method for brazed honeycomb structure was unveiled by Magnaflux of Chicago. "Bondchek" is a thermographic process in which a special heat-responsive fluid is sprayed on the exterior face of a sandwich panel. On a conveyor line, the panel then passes under an infrared heat source. Temperature differentials cause the fluid to leave warm areas and coalesce in cool spots. When the fluid is applied to a clean metallic sandwich surface, Magnaflux states, the core partitions act as heat sinks, causing the fluid to flow to the areas of good braze.

Kermit Skeie, western regional manager, stated that the method directly detects lack of braze, deformed core, ribbon direction, etc., at a maximum cost of about 17½ cents per square foot. Other defects like node flow and crushed core aren't shown directly, but, he states, tests to date show the process does give indications of them. The test coating, he claims, will stay on the panel indefinitely until removed by a simple solvent spray.

BONDCHEK processing time for a flat 10x20-ft stainless steel panel is only seven minutes, according to Magnaflux, which gave comparable times for other methods as 14 hours for ultrasonic, 10 hours for conventional X-ray, and 1⅔ hours for in-motion X-ray. Work to date indicates the method can be run at production speeds at up to 0.032 in. face sheet thickness.

Although most work up to now has been on steel, Magnaflux believes other metals, like titanium and Inconel, could also be processed. However, the method can't be applied to resin-bonded structures. Preliminary tests on welded sandwich have also been successful, it is stated.

Mach 2.5 aerodynamic heating and loads to be studied

STRUCTURE of the Bristol 188 stainless steel supersonic research plane is Firth Vickers FV 520. The two de Havilland Gyron Jr. DGJ 10 engines powering the craft have a dry thrust of 10,000 lb each (14,000 lb with reheat). Reportedly the 188 was originally intended as a research vehicle for the canceled supersonic Avro bomber. Seems that its main purpose now is the study of aerodynamic heating and dynamic loads at speeds around Mach 2.5.

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HYBRID liquid oxidizer and solid fuel rocket being developed by Reaction Motors is in the proving stage of development. A series of tests was run recently to demonstrate that the engine could be shut down and restarted without difficulty and that throttle control was possible over full thrust range.

The specific-impulse advantage of bipropellant systems over solid propellant formulas is often offset by the low bulk density of liquids. The hybrid engine overcomes this by using a solid hydrocarbon fuel instead of a liquid. The result is a gain in bulk density without a loss in specific impulse.

Huge basin being built for ASW detection gear tests

ASW TEST BASIN being built by Sperry Gyroscope at its Great Neck, N. Y., plant will be 400 ft long, 200 ft wide, and 25 ft deep. It will be used to test detection equipment being developed for anti-submarine warfare. Sperry says the detection devices it has under development promise to

more on page 36

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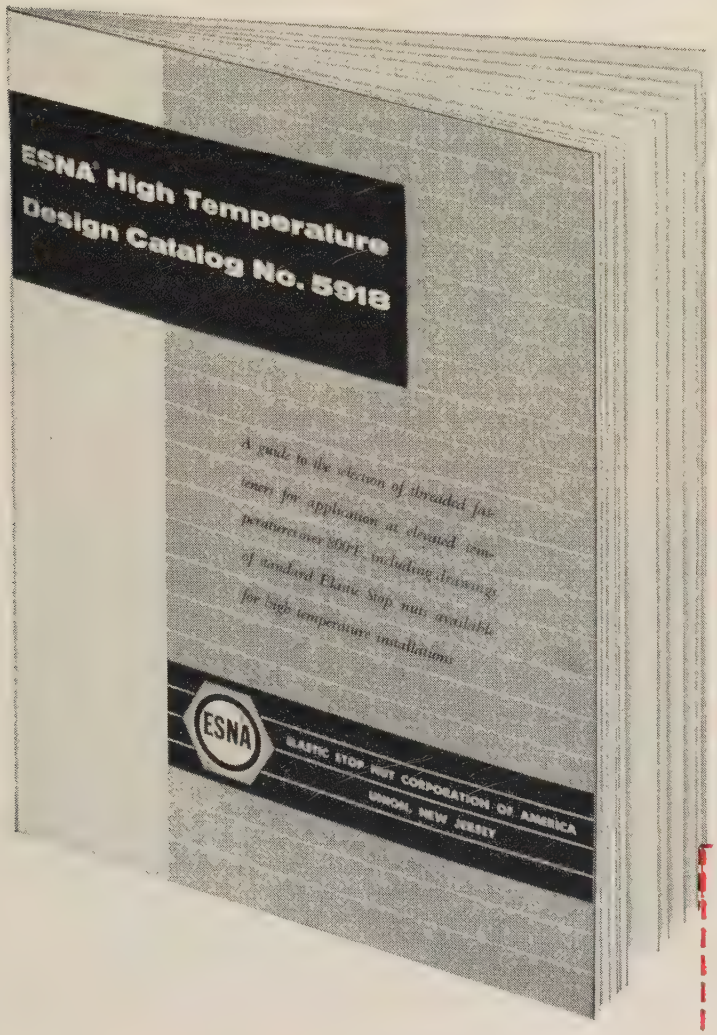

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pick out targets at considerably longer ranges and with far greater accuracy than do present operational systems.

ELECTRON-BEAM PROCESS developed by West Germany's Carl Zeiss Foundation for machining or welding of hard materials will be handled in this country by Hamilton Standard. The new process can cut holes, surface-treat, melt, or weld virtually every known material, says Hamilton Standard, including the "exotic" new metals.

Inch-thick stainless steel has been welded through in a few seconds in the lab. Half-inch stainless is the biggest size handled so far on a production basis. The process is also said to be good for milling subminiaturized electronic components.

OTHER ELECTRON-BEAM equipment is already being manufactured in this country. However, according to Charles M. Kearns, general manager at Hamilton Standard, none has reached the stage of development in controlled energy densities attained by the Zeiss process. The German method uses an extremely high voltage and a "novel" system for focusing the electron beam on the target, Kearns says.

Less powerful lower stages are foreseen for ICBMs and space vehicles

SOLID BOOSTERS seem to be edging out liquids, despite the growing reliability of Atlas. Reportedly engineers in ARPA and BMD believe Atlas will always remain a cumbersome weapon requiring elaborate countdown and servicing facilities.

More important, it is now seen that the booster need *not* have a high specific impulse or mass ratio. "Energy-wise" it is better to have high energy upper stages and a simple, relatively high thrust (1,000,000-lb), short-burning (30-second) solid booster. For ICBM or space payloads of 5-10 tons, the upper stages would probably be powered by fluorine or oxygen-hydrogen combinations.

COMPARED WITH giant solid boosters, liquids cost more to produce per pound of propellant but less per pound of overall vehicle. With solids, you can also reduce the cost of ground facilities by about 80 per cent.

In a year or two, NASA will have to make the important decision between solids and liquids in terms of such parameters as lunar soft landing, steering in space, precision velocity cutoff, and lower-stage boost.

•

DYNA-SOAR BOOSTER configuration still has not been chosen. There is some pressure on from the Space Council to use Saturn. But the talk is that AF circles consider Saturn a NASA vehicle and would rather use a Super-Titan with storable non-cryogenic propellants.

Better calibration down to two degrees K sought by NBS

LOW TEMPERATURE research program is being expanded by National Bureau of Standards. Aim is to increase the precision of temperature calibrations from 90 down to 20 deg K and provide a calibration service from 20 down to two degrees K. NBS reports that steps will also be taken toward establishing fixed points and extending the international temperature scale below 90 deg K, where there is now no international agreement. A gas thermometer may be used to make measurements in this region.

•

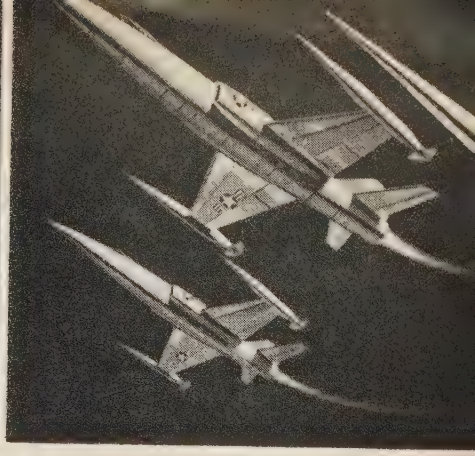
PILOT PLANT using Rocketdyne's quickmix method for continuous processing of solid propellants was recently loaded on a 30-ft truck trailer and shipped from California to Rocketdyne's facility at McGregor, Texas. There it's used to process several types of solid propellant formulations. The plant has a minimum capacity of 500 lb of propellant per hour.

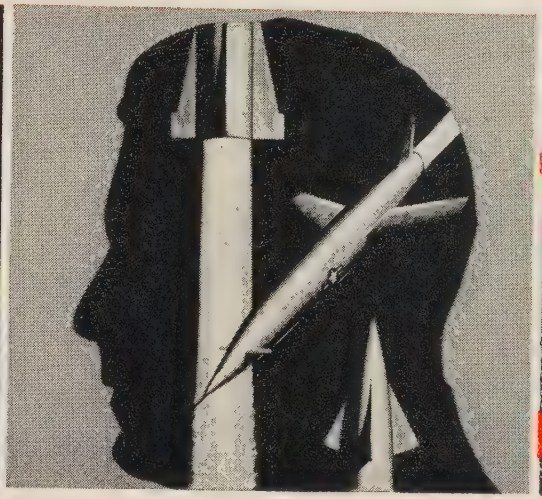
Solid propellant is blended in a matter of seconds

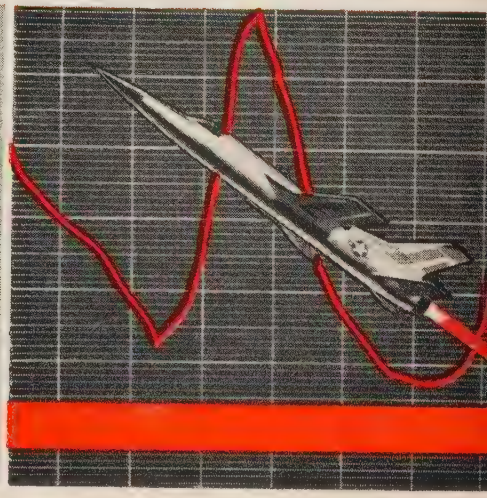
IN THE ROCKETDYNE method, the propellant ingredients are thoroughly blended in a matter of seconds, though only a small amount of material is in the mixer at any given moment. The oxidizer is dried, sifted, and ground before being dispersed in a liquid carrier. Minor dry ingredients are handled similarly. Liquid ingredients enter the system through a colloid mill and are emulsified with the liquid carrier. When metallized propellants are used, engineers say, powdered metal will also be mixed with the liquid carrier.

The streams of materials in the liquid carrier are blended at high speeds in a small mixer. Propellant formation reportedly occurs instantaneously upon contact of binder droplets and oxidizer particles.

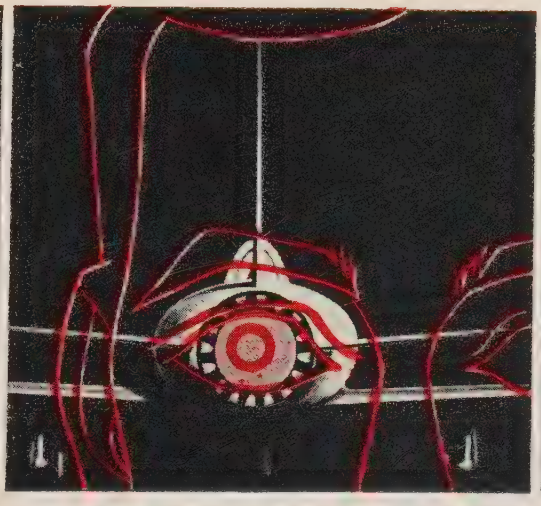
Idea sessions on going places in the sky often put the future as near as the next thought. When talk of

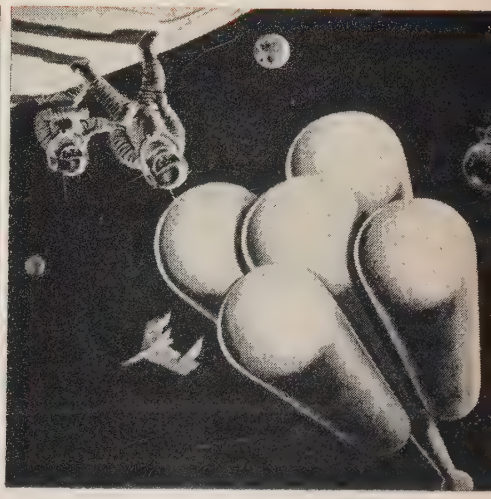






ability turns to availability, think of Ex-Cell-O for the





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calendar

February 10-12 — Seventh Annual Solid-State Circuits Conf., Institute of Radio Engineers, American Institute of Electrical Engineers, Univ. of Pa., Philadelphia, Pa.

February 16-18 — Flight National Symposium on Nondestructive Testing of Aircraft & Missile Components, Southwest Section, Society for Nondestructive Testing, Southwest Research Institute, Hilton Hotel, San Antonio, Texas.

February 18—Lecture—Astronautics & Guided Flight Section, Missile Control Problems, Royal Aeronautical Society, Institution of Mechanical Engineers, London, Eng.

February 24 — Lecture — Man-Powered Aircraft Group, Natural Flight, Royal Aeronautical Society, Institution of Mechanical Engineers, London, Eng.

February 24-25 — Fourth Annual Meeting, Biophysical Society, Sheraton Hotel, Philadelphia, Pa.

March 6-9—Gas Turbine Power & Hydraulic Conf., American Society for Mechanical Engineers, Rice Hotel, Houston, Texas.

March 9-10—The Society of Aircraft Material & Process Engineers' Symposium, Miami Hotel, Dayton, Ohio.

March 9-11—Conference on the Mechanical Properties of Engineering Ceramics, North Carolina State College, School of Engineering, Office of Ordnance Research, U. S. Army, North Carolina State College, Raleigh, N. C.

March 10-11—National Flight Propulsion Meeting (classified), Institute of the Aeronautical Sciences, Cleveland, Ohio.

March 11—Symposium on Vehicle & Instrumentation Problems in Upper Atmosphere Research, Royal Aeronautical Society, Institution of Mechanical Engineers, London, Eng.

March 23-25—Symposium on Optical Spectrometric Measurement of High Temperatures, Univ. of Chicago's Applied Science Labs, Jarrell-Ash Co., National Science Foundation, Univ. of Chicago, Chicago, Ill.

March 29-31 — American Power Conf., ASME, Sherman Hotel, Chicago, Ill.

March 31-April 1—Textile Engineering Conf., ASME, North Carolina State College, Raleigh, N. C.

April 4-8—Nuclear Congress & Exhibit, ASME, Coliseum, N. Y.

April 6-8—1960 National Meeting, "Hyper-Environments—Space Frontiers," Institute of Environmental Sciences, Biltmore Hotel, Los Angeles, Calif.

April 6-8 — Structural Design of Space Vehicles Conf., American Rocket Society, Structures & Materials Committee, Biltmore Hotel, Santa Barbara, Calif.

April 19-21—International Symposium on Active Networks & Feedback Systems, Polytechnic Institute of Brooklyn, Dept. of Defense Research Agencies, IRE, Engineering Societies Building, N. Y.

April 20-22 — National Symposium on Manned Space Stations, NASA, the Rand Corp., Ambassador Hotel, Los Angeles, Calif.

April 21-22—Southwest Metals & Minerals Conf., "Metals & Materials for the Space Age," American Institute of Mining, Metallurgical & Petroleum Engineers, Ambassador Hotel, Los Angeles, Calif.

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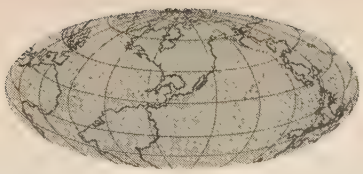
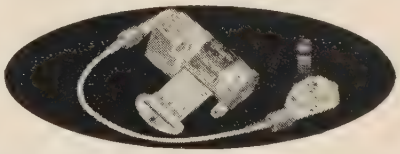


TODAY ON JET AIRLINERS* THE WIDE WORLD OVER...



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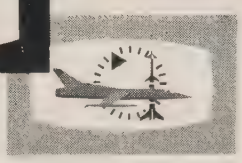

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How Ryan moved into electronics

Diversifying is easier said than done. What do you need to move into a new business? What happens to your old lines? These are the kinds of questions many aerospace firms have been asking themselves. Here is a report on how diversification worked for one company that expanded from airframes and engines into electronics.

by Robert M. Loebelson, Associate Editor

IN AN EFFORT to stabilize sales and earnings, every "old-line" company in the aerospace industry has been attempting one form of diversification or another over the past few years. But few have succeeded so well that the new areas of diversification are showing signs of providing as much income as the more "conventional" line.

One company in the latter category is Ryan Aeronautical, of San Diego, Calif. whose major diversification effort has been in the electronics field. Ryan's background in electronics goes back quite a bit, but the company's research activities in the electronics area have brought in only $2-3 million a year for the past half-decade. Yet president T. Claude Ryan expects that electronics will account for $10 million of the approximately $80 million in sales Ryan will record for fiscal 1959. Outside sources estimate that the company's electronics business in 1960 will run about $35 million, and Ryan himself has gone on record with the statement that in the next few years the company can expect to do as much business in electronics alone as its current total sales—$70-80 million a year.

The 1959 sales growth is due to initial deliveries of electronic equipment that only recently emerged from the R&D stage. Ryan's $70-80 million prediction for the near future is based on electronic equipment now in the research stage and on follow-on orders for units already in production. As the firm's president sees it, Ryan's "CW Doppler system is usable in every aircraft type from lightplanes to B-70s."

Many factors are responsible for Ryan's success at diversification. "We got into electronics," explains the firm's president, "first because we concluded there was a natural growth trend in that field and secondly as a result of the need for development of an unavailable item." He adds that "the company was fortunate in having an exceptionally talented staff that could step up our electronics work with little difficulty. We really didn't anticipate the big falling off of aircraft business. We just wanted the electronics business on top of our aircraft work."

Ryan's entry into the electronics field was largely due to the conviction that continuous-wave (CW) Doppler radar would prove superior to the pulse radar systems in existence just after the war. The Navy supported Ryan's Doppler radar research, and when, by 1957, the APN-67 automatic navigation system had been perfected, the company decided to set up a separate electronics division.

THESE TWO MEN represent a considerable span of Ryan electronics. Now director of engineering and customer relations, Owen S. Olds (left) once headed the small department that furnished the nucleus of Ryan's present Electronics Division. This division now is headed by G. W. Rutherford (right).

Ryan's Electronic Division is an extension of a small department once headed by Owen S. Olds, the firm's present director of engineering and customer relations. Its manager now is G. W. Rutherford. Early in its history, the division saw the need for a complete systems-engineering capability and therefore assembled a staff of scientists and engineers with extensive experience in the field.

Employment rose slowly but steadily, until some of the Army and Navy R&D contracts paid off in the form of production orders. The electronics operation, however, still has only one-third as many people as the major "old-line" Ryan operation at San Diego.

Electronics not taking the lead yet

Ryan does not expect the company's electronics business to surpass its other work for another two years (unless one or two large contracts now being negotiated with the Army and Navy are sewed up in the near future). Nor, of course, does he expect his company to lose out on its traditional work on account of its interest in electronics.

Some indication of the electronics progress to date at Ryan is given in the square footage and employment figures at three company facilities. At San Diego, where airframe, engine, and other "conventional" subcontract work is handled, employment stands at about 5700, and the square footage is 1,100,000. Ryan's Electronics Division occupies 100,000 square feet at the new Kearny Mesa facility (outside San Diego) and another 278,000 square feet at Torrance, Calif. Employment at Kearny Mesa and Torrance totals 1700, and is still climbing.

The Kearny Mesa installation is primarily concerned with engineering, R&D advanced design, field service, customer relations, engineering services, and associated administrative services.

The Torrance plant is used entirely for manufacture of electronic components, subassemblies, and CW Doppler systems. It has just begun delivering to the Navy the first production models of automatic radar navigation equipment. Also being produced at Torrance are various versions of the jet-powered Firebee target drone. Ryan says his firm does not include the Firebee in its electronics operation but points out that a large number of electronic components are built into each Firebee. If this Firebee work were counted with Ryan's other electronics activities, the company could well be considered predominantly an electronics firm.

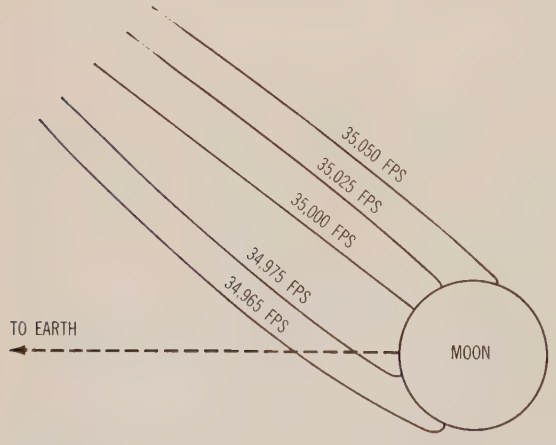
One interesting sidelight of Ryan's growth in electronics is that it has virtually no contracts with USAF in this electronics area, even though USAF has been getting more procurement and R&D dollars than the Army and the Navy for several years. In Ryan's particular electronics area, the Air Force seems to be concentrating its work with General Precision Labs, of Pleasantville, N.Y. However, Ryan still hopes to capture some USAF electronics business in the future.

In the past, most of Ryan's support in electronics has come from the Navy, and this presumably will remain so in the future. At any rate, the company is so certain that its CW Doppler work will keep it entrenched in electronics that its funds are being expended on R&D work in other electronic areas, including Doppler-inertial systems, missile guidance systems, and space navigation.—End

Landing on the moon

Courtesy of Mr. Khrushchev, we know that man can hit the moon. But that alone isn't going to get us too far—for genuine scientific achievements, we'll have to hit the moon with heavily instrumented payloads and then proceed to "soft" landings, without which manned lunar missions are unthinkable.

by Kurt R. Stehling,
Contributing Engineering Editor



DIFFERENT vehicle velocities give different points of lunar impact.

IT'S OBVIOUS that a vehicle can land on the moon in two ways:

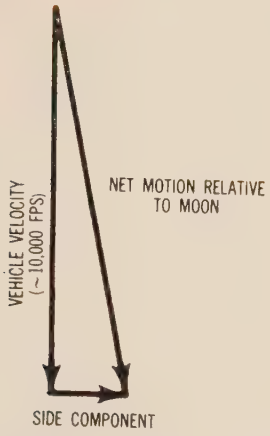
- using reaction or rocket control to achieve a "soft" impact, whose shock would perhaps be about 10 g—no more than what you get when you drop an object on the earth from a height of, say, 30-40 ft;
- in a "hard" impact involving no braking or slowing down whatever, the impact velocity being about 7000-10,000 fps and the shock perhaps as much as 500,000 g.

This 500,000-g figure assumes a hard rock surface. Unfortunately, we know so little about the moon's surface that we cannot be sure this assumption is correct. The moon may actually be covered by a layer of dust and porous rock. If there is such a layer, it favors the hard landing, which it would cushion, and raises a problem for soft impacts—landing in a cloud of dust, a vehicle might find no solid surface to rest on until it is quite buried.

One thing we know for sure: The moon has no atmosphere—or at least not enough of an atmosphere for aerodynamic braking.

Naturally the first problem of lunar landings is to make sure the last stage of your vehicle reaches the proper point near the moon from which to begin its landing maneuver and reaches it at the proper velocity. The tolerances are extremely tight—a fraction of a degree in direction and about ± 5 fps in cutoff velocity.

To study the problems of a soft landing—the only one conceivable for a manned mission—let's assume a final stage powered by a liquid rocket that has enough propellant left over after escape from the earth so that it can be used for braking near the moon. We'll also assume that this engine can be used to cancel out the velocity side component imparted by residual velocity differences between the earth's and the moon's paths in space. This side component would



SIDE COMPONENT of velocity caused by the earth's motion contributes to the actual motion of a moon vehicle.

be measured by a sensor system (optical devices and a setup using earth-based telemetry stations are possibilities) whose signals then would point the engine off-axis in its gimbaled mounting.

Perhaps the most difficult problem with such a lunar vehicle is that it originally approaches the moon with its engine exhaust pointing normally out the rear —yet for braking of course the exhaust must point toward the moon. The vehicle therefore must be turned around, or flipped over, in space. Before and during the flipover, the engine's propellants will slosh and may even be in a free-fall condition, which raises all sorts of interesting problems. To overcome these, pressurizing bladders, piston tanks, or small gas jets providing continuous positive acceleration must be used.

Perturbations during the descent

The propellants probably will slosh after the flipover, too, causing vehicle perturbations during the actual descent to the moon. Furthermore, during retrofiring, the hydraulic propellant head will change. By proper baffling and with a design stressing high hydraulic rigidity, these effects can be minimized.

Since a soft moon landing obviously is a very tricky maneuver, flow control reliability in the propulsion system is of the first importance. All controls, for instance, must be designed for quick start and shutdown and must have seals that do not deteriorate under prolonged exposure to cryogenic propellants and radiation in space. (The last requirement naturally applies for all radiation-sensitive materials used in the vehicle.)

When it comes to choosing a propulsion, or braking program, for the moon landing, the designer can at least take comfort in the thought that acceleration due to gravity is less of a problem than usual—be-

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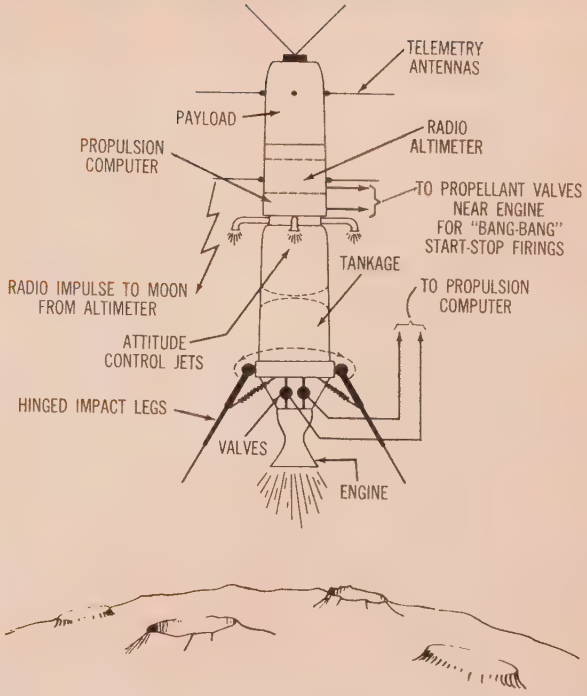
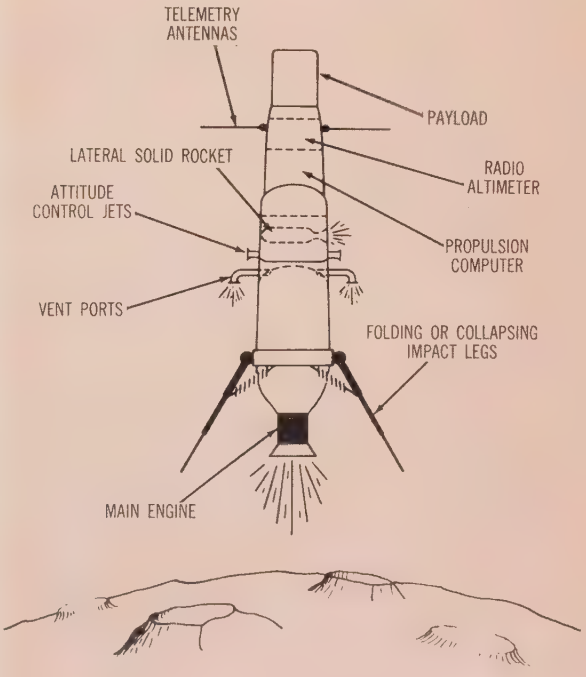
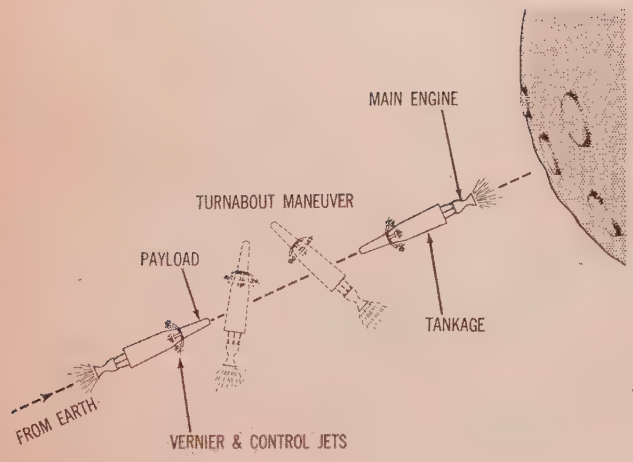
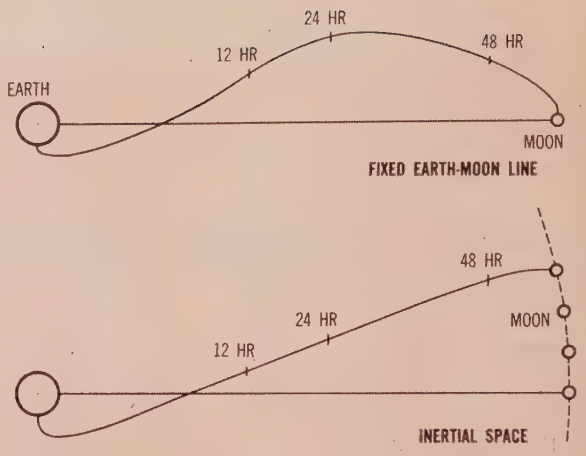


IN A LIQUID ROCKET vehicle (above) for soft moon landings, the propulsion computer uses the radio altimeter's output to calculate a firing program for the main engine that will give the proper deceleration. The gimbaled main engine also can be used for steering. The attitude control jets cancel the side velocity. The impact legs are locked alongside the tanks during flight. Below: Solid rocket system for a soft moon landing is simpler than a liquid one and perhaps also more reliable. However, it lacks flexibility. The lateral rocket cancels the side velocity. The simultaneous ignition of the main and lateral engines must be very precisely timed.





LAST STAGE of a moon vehicle could also be used for retrofiring preparatory to a lunar landing.



LUNAR rocket vehicle trajectories assuming a fixed earth-moon line and in actual inertial space.

cause of the moon's smaller mass, one lunar g equals only one-sixth of an earth g. Next comes a rather uncomfortable question: Just what kind of a braking program is best?

Should the designer plan for a smoothly variable descent? This adds complications, since the engine would have to be throttlable. Or should he set up a "bang-bang" system, with the engine starting, stopping, and restarting until the velocity has been trimmed down enough? In this case, flow control reliability is really at a premium. Or should the vehicle expend all its propulsive braking energy in a single burst, which would have to be timed and adjusted in magnitude and direction with the most rigorous precision?

If a bang-bang program is chosen, hypergolic, or self-igniting, propellants reduce the danger of ignition troubles. On the other hand, such propellants increase the danger of explosion or fire upon impact. In this situation, the considerable amount of work done (especially by General Electric) on auxiliary slugs of hypergolic propellant assumes great importance; such slugs could be used to ignite a non-hypergolic main propellant.

Altimeter and computer to be used

To control the braking program, a radio altimeter and a computer will most likely be used. The altimeter would feed highly accurate height measurements to the computer, which would use these and computations of the rate of descent to ignite, throttle, or stop and re-ignite the engine (depending on the type of braking program).

As we've just noted, there is a decided danger that (even in a vacuum) liquid propellants will react with each other upon impact and cause a fire or an explosion. At least one of the propellants, therefore, should be completely disposed of by the time of impact. A very precise burnout program could take care of this requirement, or quick venting and vaporization at impact.

During the descent to the moon, the rocket exhaust generally will "balloon" outward, as in any vacuum. However, because of the considerable downward velocity and because of lateral components in the exhaust, it is still possible that some of the exhaust gases will flare back and coat or mar the payload with its sensitive optical and electronic devices. Extra-large exhaust nozzles or special payload protection might prevent (or at least reduce) such effects.

Engine shut down before impact

Ground blast also poses a serious problem. Even if the engine shuts down precisely at the moment of impact, a great deal of dust is raised (*if* there is dust on the moon) that might be very harmful to vehicle and payload. A solution here would be to use long, extendable tripod landing legs and shut down the engine before impact.

No matter how precise the propulsion program is, some special mechanical or reactive shock-absorbing device almost certainly will also be required. Proximity fuzes, for instance, could be used to actuate gas jets that will provide a final cushioning effect.

Another precaution that in the end might have to be taken is blowing off the payload at the moment of impact—no harm could then be done if the propellants explode. An expandable impact bag triggered by a proximity fuze or an accelerometer might be used to soften the payload's impact on the ground.

An auxiliary gas system will have to be provided

for tanks and bladder pressurization, auxiliary power, and at least roll control (assuming the main engine takes care of pitch and yaw control). A lot of work has already been done on small gas systems, and the designer should have no trouble adapting one of the existing configurations to the purposes of a lunar vehicle.

It can be argued, of course, that it is inefficient to land the entire last stage of a vehicle on the moon, which would mean decelerating a mass that may weigh some five tons or more in order to preserve a payload of around 200 lb. The alternative would be to include a separate propulsion system in the payload, which then actually becomes the last stage. In this case, the designer most likely would choose either a solid rocket or a storable liquid system.

Solid rockets pose new problems

If a solid rocket is used to provide the retro-thrust for a lunar landing, several special problems arise:

- Overall attitude control would have to be very precise and highly effective, since the rocket almost certainly would not be gimbaled.
- To cancel velocity side components, small, sideways-firing solids might be used.
- Ignition and total burning impulse would have to be timed and predicted very precisely for both the retro-firing main rocket and the sideways-firing rockets, since none of these is at all likely to be run in throttling or start-stop operation — controllable solid rockets would make the design problem just too tough. The propellant grain would have to be of the highest quality.

High ignition reliability will be essential for the solid rockets. In addition, the main engine will have to have a short combustion rise time and an accurately predictable total impulse, so that the designer can make sure it will stop firing shortly before or on impact. It may prove possible, though, to cut off propulsion by means of rupture disks; in this case, the requirements for control accuracy would be slightly reduced.

Hard moon landings, of course, are already a reality—the Russians made one last year. For reasons best known to themselves, they did not use fluorescent powders or dyes or a proximity fuze to show the point of impact. It seems likely, therefore, that their vehicle didn't carry much (if anything) in the way of instrumentation for exploring the lunar surface. Yet lunar exploration is about the only meaningful scientific use to which a hard landing on the moon can be put.

Crude guess about lunar surface

Just from a hard impact itself we could, for instance, learn something about the surface of the moon. A transmitter carried by the impacting body and designed for a narrow bandwidth (as would be the impact sensors) could send out a deceleration pulse as it penetrates the top layer of the moon. Knowing the impact velocity and the density of the impacting body, we could use the shape of this pulse as the basis for a crude guess about the density of the lunar surface. It would be possible to encapsulate the transmitter in soft plastic that could withstand an impact shock as high as 300,000 g.

The transmitter's output would not have to be large —existing radio telescopes are sensitive enough for the detection of a ¼-W beacon transmitter that is radiating even only a fraction of its power toward the earth at very narrow bandwidths.

Radio transmission from a body that has hit the moon poses some intriguing problems. For instance, what if the moon indeed has a deep top layer of dust or porous rock and the impacting body buries itself in its own crater? To insure transmission, the impact body might carry armored trailing antennas that will not rip off on impact and are long enough so that their ends will flop on the moon's surface no matter how deeply the impact body digs itself in.

Another idea would be to pack some thermite into the impact body. This self-oxidizing material would vaporize or even ionize some of the lunar surface on impact. A spectrogram of this effect, obtained by powerful telescopes on the earth could then be compared with a spectrogram taken before impact. The result would be at least a qualitative indication of the properties of those lunar substances that can be ionized to the degree necessary for spectral emission.

Impact must be known accurately

In this kind of experiment, the point of impact would have to be predicted with great accuracy, so that the telescope could be oriented beforehand. The trouble is that the thermite flash would last only a few seconds, while an exposure of at least 10-20 seconds is needed for a good spectral photograph.

Another doubtful point is whether thermite would have enough of an ionizing effect—maybe a fluorine-lithium combination would have to be used instead to provide a hotter flame. Small nuclear charges have also been proposed, but these appear to be technically impractical (quite aside from the risk of getting everyone mad at us for contaminating the moon).

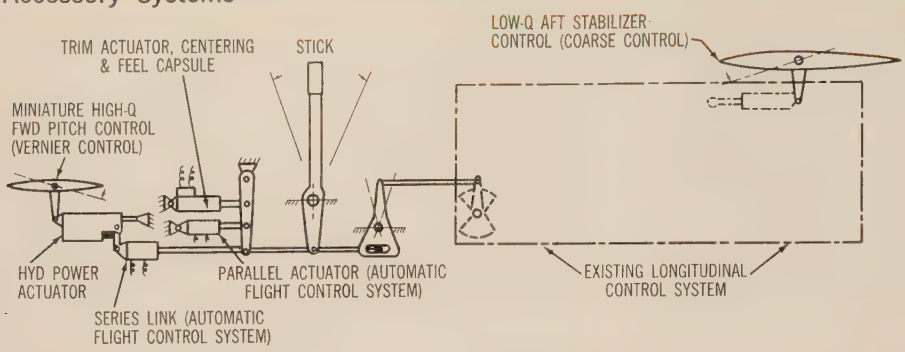
Naturally, we could also get a lunar spectrogram after a soft moon landing with a body instrumented to vaporize small quantities of lunar substances in an electric arc. This is a much more difficult proposition, though, on which considerable development work remains to be done.

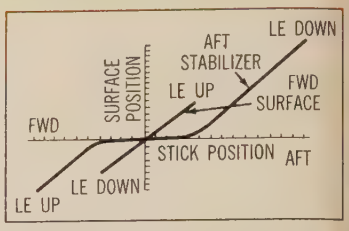
Whether the landing is hard or soft, the payload limit for lunar vehicles will be the same for the next few years—100-500 lb. For a hard impact, much of the payload is taken up by protective cushioning; for a soft impact, about the same payload fraction is needed for retro rockets and braking control equipment. The useful payload fraction will increase with overall payload size.

Much earthbound ground testing obviously will have to precede any extensive program of lunar exploration, especially before soft landings. To simulate the impact conditions, payloads may have to be dropped from airplanes, fired into the earth, and ejected from ballistic mechanisms. Actually, soft landings will be very hard to simulate accurately, since we will be hampered by the earth's atmosphere and relatively high g-force. It seems certain, therefore, that the first soft moon landings will be unmanned, too—only in that way will we be able to make reasonably sure, for instance, that the first man on the moon will not plunge into a deep layer of dust and never be heard from again.—End

REFERENCE—H. A. Lieske, "Lunar Trajectory Studies;" Rand Paper P-1293 ('58).

Accessory Systems


TRIM ACTUATOR, CENTERING & FEEL CAPSULE
STICK
LOW-Q AFT STABILIZER CONTROL (COARSE CONTROL)
MINIATURE HIGH-Q FWD PITCH CONTROL (VERNIER CONTROL)
HYD POWER ACTUATOR
PARALLEL ACTUATOR (AUTOMATIC FLIGHT CONTROL SYSTEM)
EXISTING LONGITUDINAL CONTROL SYSTEM
SERIES LINK (AUTOMATIC FLIGHT CONTROL SYSTEM)



LAYOUT and operation of a two-phase control system adapted from a conventional mechanical-hydraulic system. Q is airspeed dynamic pressure.

Flight controls:
a look into the future

We should start right now on the development of flight control systems for tomorrow's advanced aerospace vehicles. The challenge is certainly big enough for an early start: We need systems that will operate over a speed range from zero to Mach 18, withstand temperatures of over 1000 deg F, and work equally well inside and outside the atmosphere.

by Harry E. Arnzen, Senior Engineer,
Design Safety & Reliability Dept., Republic Aviation Corp.*

THE PROBLEMS we face today in the design of flight control systems are tame compared with those we will run into over the next 10 years. In manned vehicles, in particular, flight control systems will have to perform reliably over a wide spectrum of altitudes, speeds, and temperatures—and that within both the earth's atmosphere and out in space.

* Republic Aviation Corp., Conklin St., Farmingdale, N. Y.

The performance demands on future flight control systems will be directly related to the type of propulsion system used to power the vehicle. The flight control designer therefore must have a clear idea of the direction in which powerplants are developing.

From 1960 to 1965, we will see a big increase in the thrust of operational turbojets, turboprops, turbofans, and turbo-ramjet combinations. For operation outside the atmosphere, we can expect to see the fully throttlable liquid rocket engine powered by high energy fuels.

Between 1965 and 1970, it appears, nuclear propulsion systems will become operational, including direct- and indirect-cycle turbine types and ramjet types for the atmospheric flight. Depending on funding, the ion jet, the plasma jet, and the atomic rocket may be ready for operation beyond the atmosphere.

New systems for exotic engines

Special flight control systems will have to be developed to match the more exotic of these propulsion systems. In some instances, it may be enough merely to divert some of the thrust for control purposes. But in the main it will be necessary to provide full-fledged auxiliary control.

Future control systems will have to work at top flight speeds ranging from Mach 2 up to suborbital velocities at the fringes of our atmosphere. Some of the outstanding design requirements will be:

- finer degrees of vernier control—above hypersonic speeds, the mechanical parts of the flight control system may well have to be designed and built to precision-instrument standards to provide the required degree of incremental control;
- completely developed and test-proven "spectra" of materials and lubricants that flight control systems might use from Mach 2 to 20 and in related increments at temperatures from —100 to 5000 deg F;
- composite "all-altitude" control systems for operation within the atmosphere (using aerodynamic control) as well as in the near-vacuum of space (using reaction jet control, steerable exhaust vanes, nozzle control, etc.);
- boundary layer control for *all* control surfaces to improve controllability above 60,000 ft—conceivably the effectiveness of conventional control surfaces could be extended to 100,000 ft in this way.

Vernier control for Mach 2 plus

Vernier control starts to become really important for small or near-neutral control displacements at speeds beyond Mach 2. Particular attention must be given to the mechanical part of the flight control system. You can only get vernier control if friction, slop, backlash, stretch, and deflection in the control linkages are kept to a minimum. Bearings are important, too—they should provide slop-free operation at all temperatures.

The variation of control sensitivity with speed is another important factor. It becomes most critical when the airspeed dynamic pressure is highest—at maximum speeds and minimum altitudes. Provision must be made for automatic de-sensitizing of the surface response by such means as a variable mechanical advantage shifter, motion de-sensitizing linkage, and a motion damper.

Some high speed aircraft have dangerously poor longitudinal pitch-up stability characteristics. To safeguard the structure in such a case, a load-factor-limiting device must be inserted into the flight control system to maintain a nominal eight- or nine-g limit under normal flight conditions. (An override must be added to allow the pilot to exceed this limit to avoid possible collisions with other aircraft or to clear the ground in recovering from a dive.)

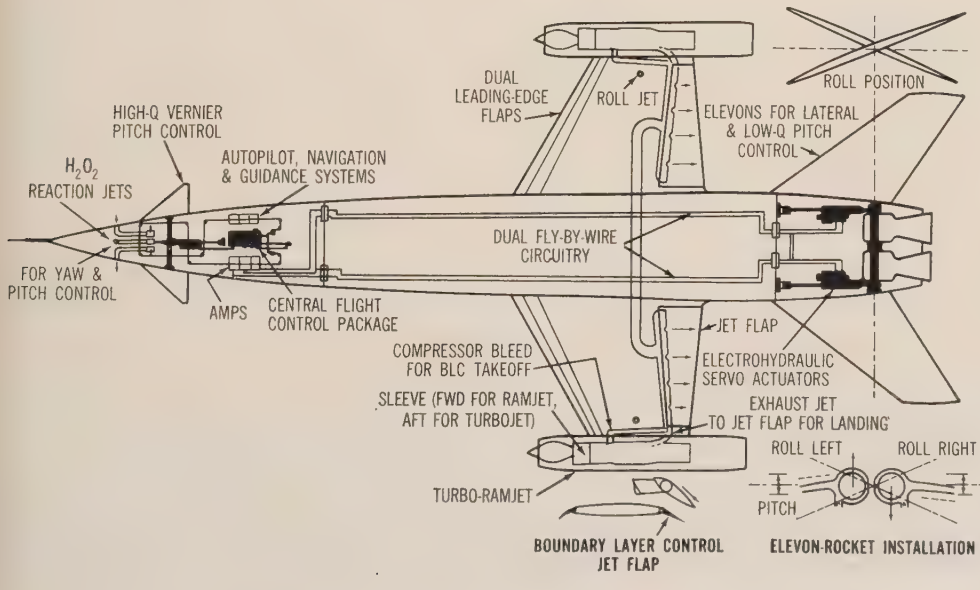
Aerodynamic heating causes problems

Automatic pitch trim is needed in all modes of operation (automatic or manual) to compensate for transonic pitch trim changes and operational trim changes. The latter would include trim changes required because of landing gear extension or retraction, use of a thrust reverser in flight, use of boundary layer control, or use of jet-flap-modulated lift control.

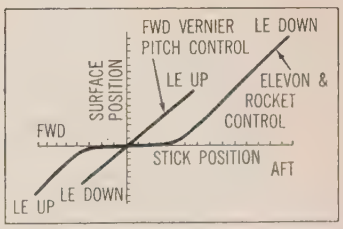
Most of the high temperature problems of advanced designs will result from aerodynamic heating. Even with airframe and equipment cooling, the flight control system will have to operate in temperatures over 1000 deg F. Therefore, moving parts and assemblies will have to be made of compatible materials. The coefficients of thermal expansion and rates of expansion of interconnected members will have to be similar, so that the control system geometry will not change (unless compensated for) and parts will not bind.

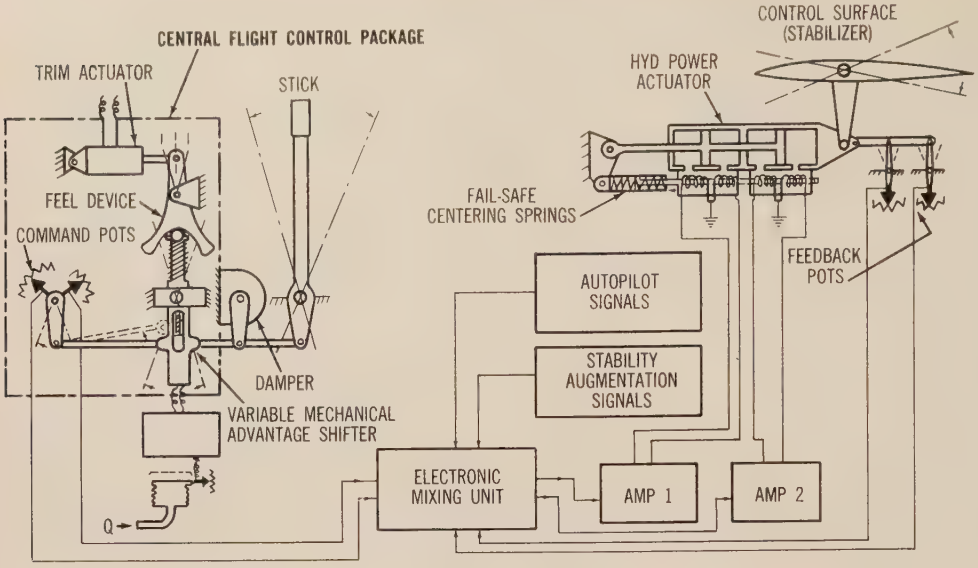
Bearings exposed to high temperature should not be pressed into housings with an interference fit. Instead,

more on next page

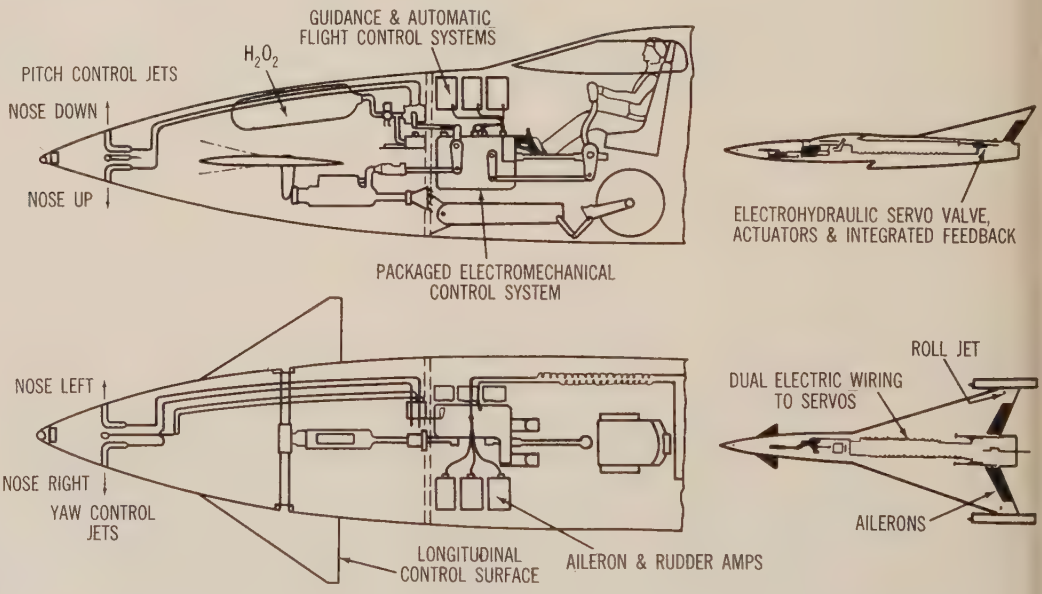


LAYOUT and operation of an all-altitude flight control system for vehicles flying at Mach 3 to 5+.





A TYPICAL central flight control package has a variable mechanical advantage linkage and damper to vary the pilot's stick forces as a function of the airspeed dynamic pressure.



ALL-ALTITUDE packaged flight control system in a typical canard-delta installation. The attitude control reaction jets are used in the upper atmosphere.

they should be held in place by retention plates, threaded retainer rings, safetied set screws, or similar devices. In cases in which there is a large difference in the thermal expansion coefficients of a pressed-in annular bearing and its housing, it may be advisable to separate the bearing from the housing by a "serpentine" ring. This will prevent both binding and excessive looseness at either very high and very low temperatures, respectively.

At temperatures of more than 1000 deg F (for which no lubricants are available right now), it is advisable to use bearings or bushings that have a certain amount of self-lubrication. For instance, balls made of Haynes Stellite (or some similar high-cobalt-base metal) and sintered chromium-carbide might be set in an outer race using the same material or Inconel-X. Other promising bearing materials for temperatures approaching 2000 deg F include Corning Pyroceram, ceramics, and sapphire.

For bearings and bushings that are fairly accessible

and so can be changed often, tool steels like M-2, M-10, M-50, Halmo, DBL-2, etc., all show considerable promise for highly loaded operation at less than about 900 deg F maximum. However, in oxidizing atmospheres, these tool steel materials would have to be protected against corrosion and a dry-film lubricant would have to be applied to the wearing surfaces periodically.

Automatic transition is necessary

Increasing altitude capabilities pose the need for composite all-altitude flight control systems. Most probably, conventional aerodynamic-type surface controls will be used in the atmosphere and reaction control jets (augmented at times by the action of gimbaled engines) in space. The transition from one type of operation to the other will have to be made automatically both upon leaving and upon re-entering the atmosphere.

It will take a fully integrated electric, electronic, and hydraulic flight control system to provide automatic transition. The integrated electronic portion no doubt will involve a "marriage" of the flight control, navigation, inertial guidance, and fire control systems. Even though weight and space will be at a premium, we will probably have to include a redundant standby flight control system that will automatically switch into operation in case of trouble in the primary system. This automatic standby system in turn would have to be backed up by a simplified, manually operated, all-mechanical system for primary control within the atmosphere and for actuation of emergency reaction jets in space.

BLC for use in "thin" atmospheres

Boundary layer control is usually used to maintain laminar flow over an airfoil section to increase lift for shorter takeoffs or landings. However, it can also be used to improve the effectiveness of control surfaces in a "thin" atmosphere. Here is how a typical aileron control augmentation system would work: Pressurized air bled from the final stage of the gas turbine compressor is ducted to a proportional flow-rate valve operated by the boost actuator of the pilot's control stick. When the stick is moved to the right, the air valve ports a flow of air to spanwise nozzles on the upper surface of the lowered left aileron. No air is ported to the raised right aileron. The result is an increase in the lateral control rolling moment (caused by the increased lift of the lowered aileron) and so an increase in the effective moment arm force. Rudder and elevator control could be augmented in similar fashion.

Development should be started now

There is no doubt that a long term development program should be started now to meet the control needs of future aircraft and aerospace vehicles. Such a program might undertake the following projects in the order listed:

(1) apply a combination of aerodynamic and mechanical concepts to improve existing, highly refined mechanical controls systems so that they will provide vernier control for near-neutral displacements at speeds over Mach 2;

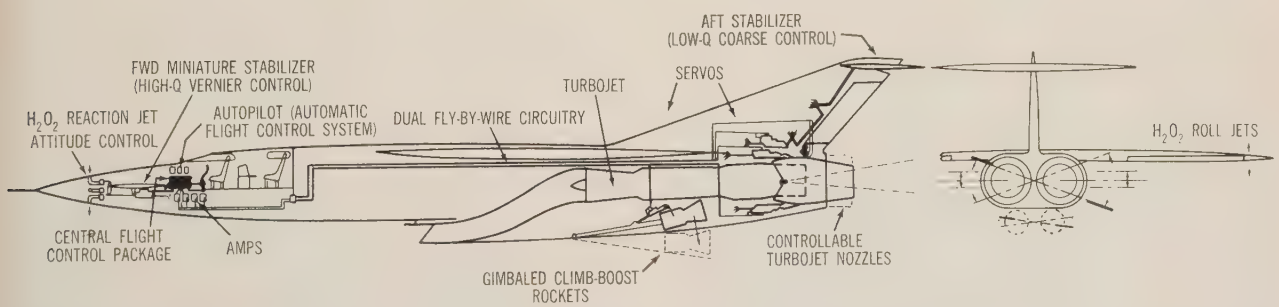
(2) develop a boundary layer control flow system for all present types of three-axis control systems to extend their maneuverability range to 100,000 ft;

(3) develop "limited authority" electronic control systems with mechanical standby control linkages that could be used to operate a hydraulic servo;

(4) study, develop and test different electrohydraulic servo loop configurations to evaluate the relative merits of electronic feedback, electromagnetic torque motor control, hydraulic amplifiers with integrated mechanical feedback, etc.;

(5) explore the possibilities of integrating an all-electronic flight control system with automatic navigation, guidance, and fire control;

(6) search for possible configurations of an all-mechanical control system, capable of withstanding re-entry temperatures of over 5000 deg F, for Mach 18 boost-glide vehicles—since no rapid maneuvering would be needed at high re-entry velocities, this system might resemble that of an automobile, and contain shafts, gear sectors, worm drives, and multi-rotational input control wheels.—End



A MACH 2-4 VEHICLE might use this all-altitude control system. The two stabilizers would be used during flight in the atmosphere, the controllable turbojet nozzles in the upper atmosphere, and the H_2O_2 reaction jets outside the atmosphere. The roll jets in the wings would be fired up and down for pitch control and differentially for roll control. The central flight control package would contain a pitch damper, a mechanical advantage shifter, a parallel actuator (for the automatic flight control system), a feel device, a trim actuator, and command potentiometers for rudder, aft stabilizer, ailerons, rockets, and turbojet nozzle actuators.

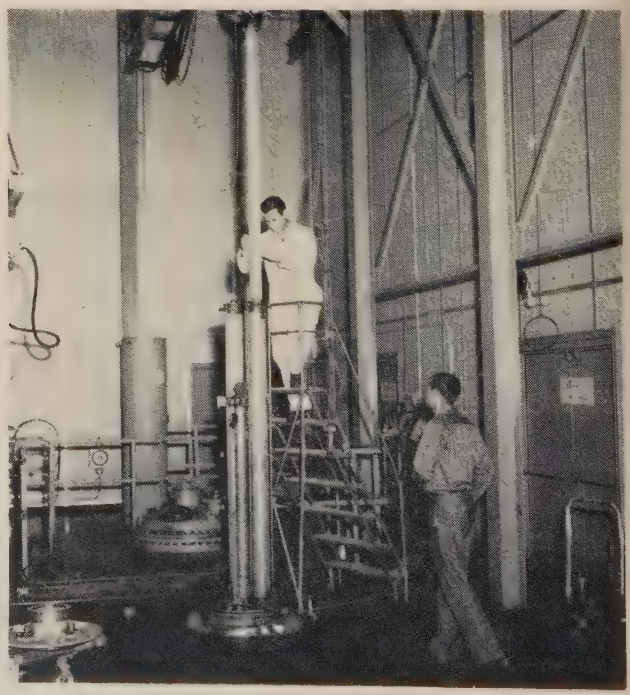
Bottom-casting forms

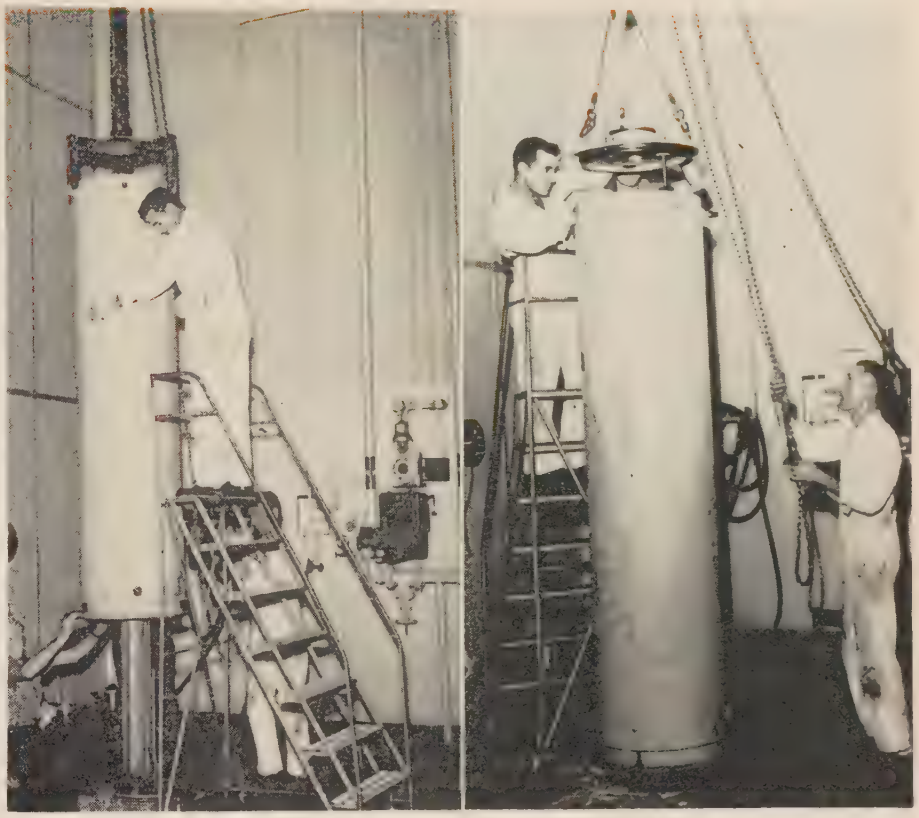
narrow solid propellant shapes

CONVENTIONALLY, cast solid propellant shapes are made by vacuum casting or by bayonet casting, in which a thin ribbon or propellant is forced into place through a narrow tube. However, when the propellant has to be forced into a long, narrow cavity, it's hard to get up the pressure needed to pack the propellant uniformly in place. To solve this problem, engineers at Solid Propulsion Operations, Rocketdyne Div., North American Aviation, Inc., McGregor, Texas, decided to bottom-cast the propellant, using a diaphragm under pressure to force the propellant up into the rocket case.—**IS**

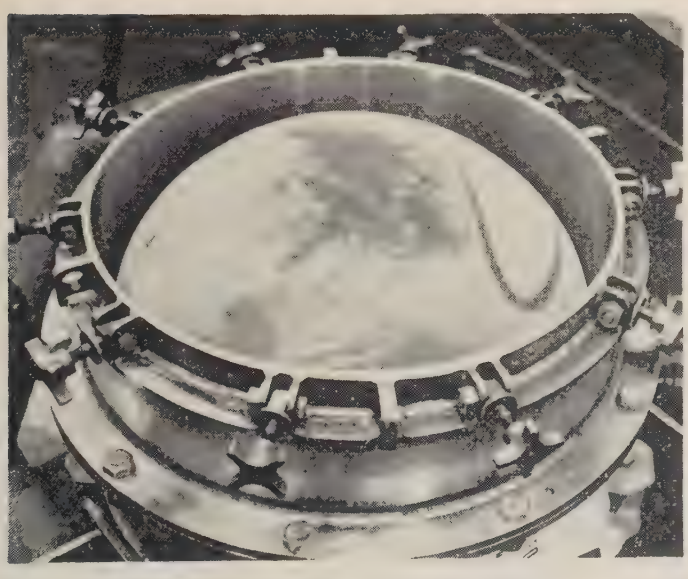
1 Preparing for bottom-casting, workman sprays silicon on Teflon-coated aluminum mandrel, which then can be removed more easily after curing. Left of the mandrel is a holding jig with two rocket cases.

2 Mandrel is lowered into the rocket case. Cases are held in jigs by full-length tie-rods and sealed at the bottom with O-rings. Grooves on the mandrel determine the burning properties of the rocket.



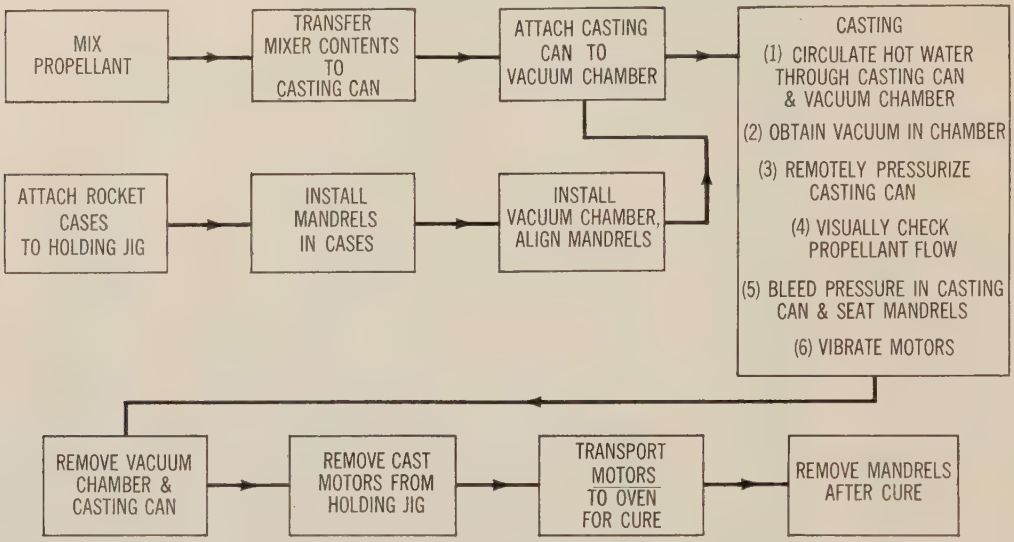


3 Combination vacuum chamber and heating jacket is lowered over cases (near right). The unit contains spiral tubing on inner wall for hot water to maintain the proper temperature during casting. The chamber is locked to the holding jig with swing bolts and sealed with an O-ring. Far right: Chamber lid is positioned. Mandrel actuator rod under the lid permits up and down adjustment of mandrels during the process to help control the propellant flow. It also is used for seating the mandrel inside the rocket case after casting.

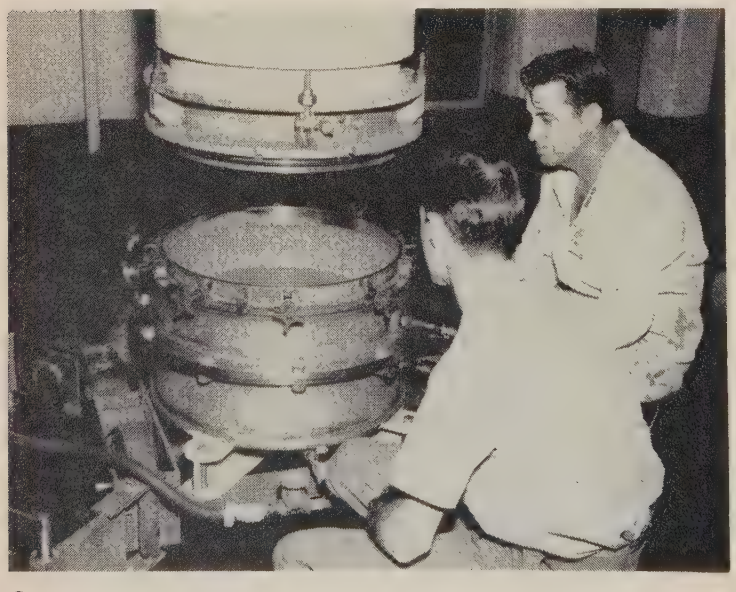


4 Closeup of the casting can with its rubber diaphragm in the inflated position. The diaphragm is lowered to the can bottom before the propellant is poured in. The thickness of the rubber varies from about ¼ to ½ in. Also before the propellant is poured, a viewing glass is positioned on top through which the propellant flow can be checked. The glass and the chamber lid are held in place by the casting vacuum.

5 Propellant is scraped into the casting can from a 25-gal mixer. As used at the Solid Propulsion Operations plant of North American's Rocketdyne Division the final mixture in the can of oxidizer, binder, and other ingredients weighs about 200 lb.

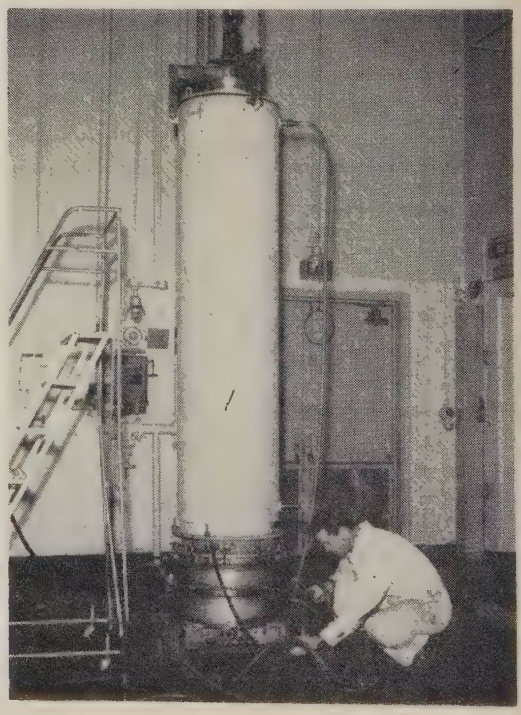

MIX PROPELLANT
TRANSFER MIXER CONTENTS TO CASTING CAN
ATTACH CASTING CAN TO VACUUM CHAMBER
CASTING
(1) CIRCULATE HOT WATER THROUGH CASTING CAN & VACUUM CHAMBER
(2) OBTAIN VACUUM IN CHAMBER
(3) REMOTELY PRESSURIZE CASTING CAN
(4) VISUALLY CHECK PROPELLANT FLOW
(5) BLEED PRESSURE IN CASTING CAN & SEAT MANDRELS
(6) VIBRATE MOTORS
ATTACH ROCKET CASES TO HOLDING JIG
INSTALL MANDRELS IN CASES
INSTALL VACUUM CHAMBER, ALIGN MANDRELS
REMOVE VACUUM CHAMBER & CASTING CAN
REMOVE CAST MOTORS FROM HOLDING JIG
TRANSPORT MOTORS TO OVEN FOR CURE
REMOVE MANDRELS AFTER CURE

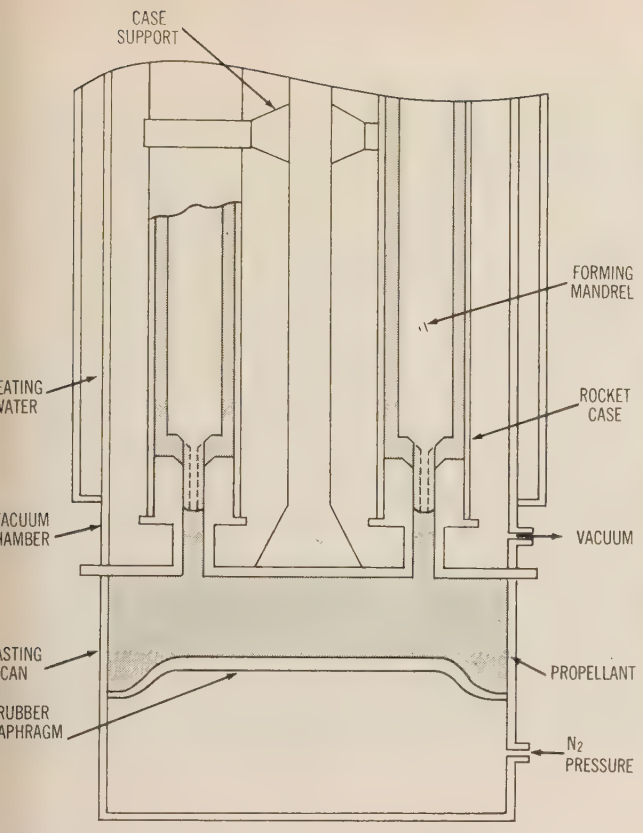
FLOW DIAGRAM of bottom-casting process (above) used by North American's Rocketdyne Division at its Solid Propulsion Operations plant in McGregor, Texas. This process was adopted mainly because it insures uniform propellant distribution inside a long, narrow cavity. Right: Cutaway sketch of the casting setup. After casting, the mandrels are lowered into the base of the rocket to prevent propellant seepage through the bottom.

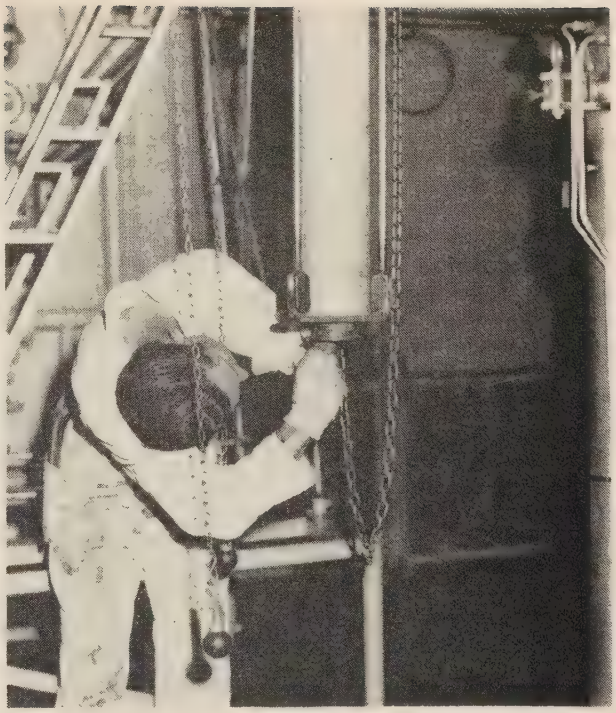


6 The casting is bolted to the bottom of the vacuum chamber.

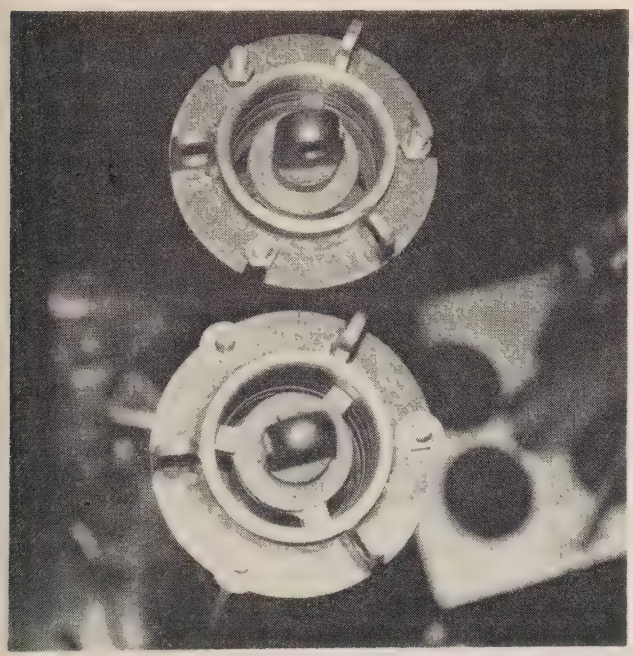
7 Nitrogen line is connected. Later it is remotely controlled to force propellant into the cavity. The hoses running up the side of the vacuum chamber circulate hot water to keep the propellant at 160 deg F.





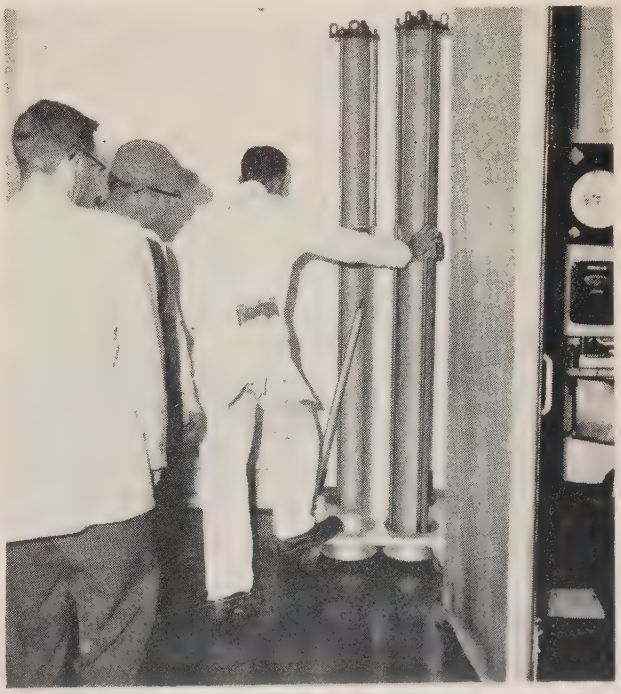


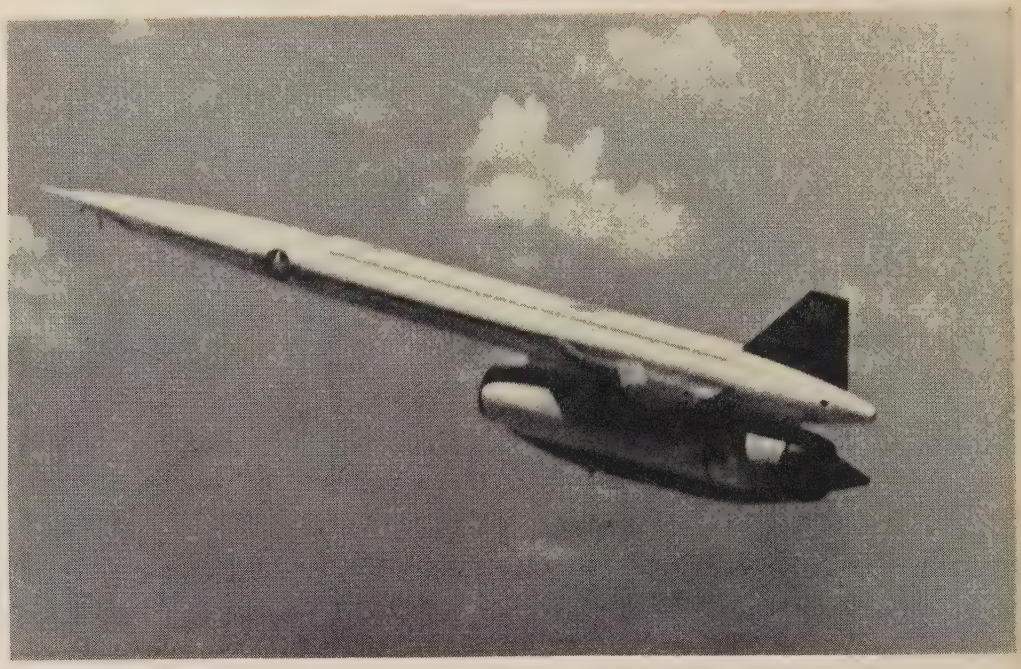
9 Motors are lifted from the holding jig so that execss propellant can be cleaned out of the case bottom. The bottom of the tierod assembly and the Marman clip around which the O-ring fits for tight sealing are visible near the operator's hand.



Top view of cases after casting has been completed and the vacuum chamber has been removed. Before the chamber is removed, the motors are vibrated to aid in proper settling of the propellant.

10 Motors are rolled into oven for 48-hour cure at 170 deg F. After the cure, the mandrels are removed and the propellant is trimmed and machined in preparation for test firing.





HOUND DOG in flight. The missile is powered by a P&WA J52. The spike in the engine exhaust controls the cone angle to eliminate burbling.

Hound Dog

designed for

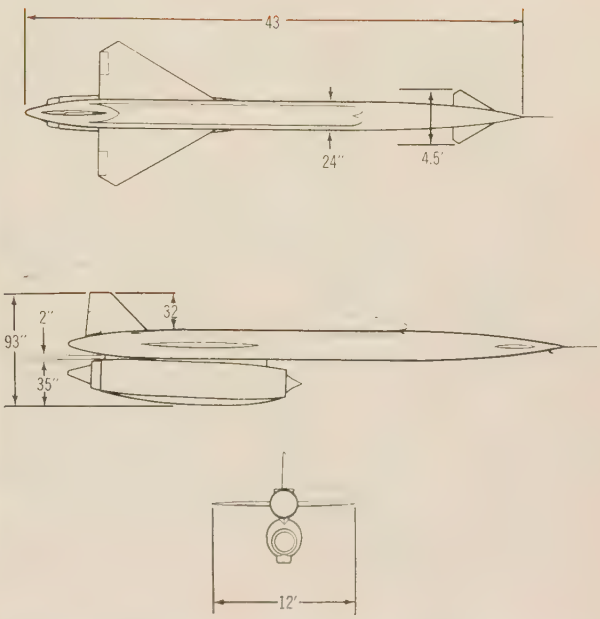
off-the-shelf reliability

SAC's B-52 fleet probably represents the bulk of the immediate striking power available to the U.S. today. To keep this deterrent potent until the next generation of weapons becomes operational, a stepped up capability was needed. Here's how the Hound Dog missile was designed to fill this need in less than 2½ years.

by Irwin Stambler, Associate Editor

WHEN THE FIRST production model of North American Aviation's GAM-77 Hound Dog air-to-ground missile was accepted by USAF late last year, only about 28 months had passed since design work had been started. There was a special reason for the fast development of the jet-powered Hound Dog: Designed to extend a weapon with which to strike targets from a distance, the missile would fulfill its purpose only if it could be gotten into operation as quickly as possible.

To cut down on development time, North American Aviation, Inc., International Airport, Los Angeles 45, Calif., decided to use as much off-the-shelf equipment of proven reliability as possible. The Hound Dog's fuel pump, for instance, is also used in a Convair design, and the heat exchanger, a Stewart-Warner model, was first used by McDonnell. Of course, in some cases off-the-shelf items couldn't meet the requirements. Then



FRONT VIEW of Hound Dog (above) in position on B-52G shows aluminum engine inlet spike. Right: Three-view of Hound Dog shows long, slim fuselage. Electronic gear is installed in the nose section, the fuel tank in the aft fuselage area. Except for the length, all dimensions are estimated.

there were also cases in which requirements could be met by available hardware that had been underrated.

In such an "off-the-shelf" program, NAA engineers state, the secret of success is not to try to optimize the design right at the start. If you try to optimize, they emphasize, "you're always a day late and a dollar lost." For instance, NAA decided not to try to optimize the aerodynamic control surfaces at the outset, but rather use shapes based on experience with the X-10 and G-2C test vehicles. Similarly, it decided from the start that the fuselage would be a simple body of revolution, so that it could be built easily.

The Hound Dog's fuselage—like just about all the missile's structure with the exception of "hot" engine areas—is made of 2024ST aluminum. It is long and slim; its designers originally aimed for a fineness ratio of 20, but for aerodynamic reasons ended up with a slightly lower ratio. Part of the missile is a welded structure made up of a series of forged rings and thick cylindrical skins forming the integral fuel tank.

The nose cone is attached at station 175. From this point forward, the internal structure consists of a long I-beam on which the guidance and temperature control, and other electronic systems are installed. After removal of a ring of bolts at station 175, the whole nose cone can be removed to expose all equipment for maintenance.

As NAA engineers told SPACE/AERONAUTICS, the

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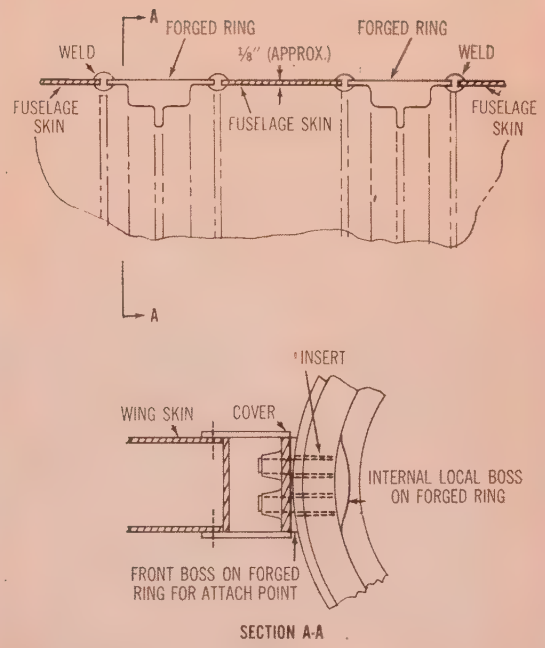
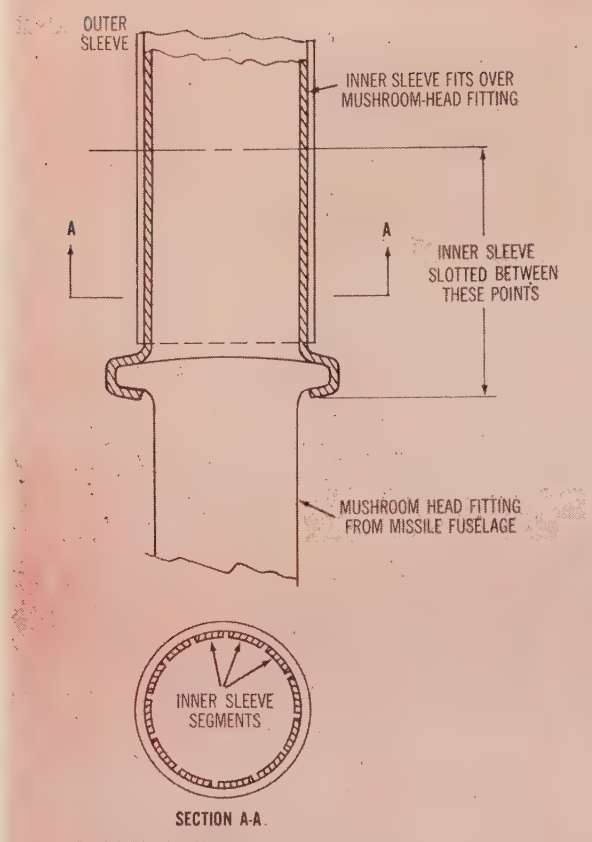


MAIN PART of the fuselage is an integral tank formed by a series of welded forged rings and cylindrical skins. Some of the forged rings also serve as wing attach points, while others are used for the pylon and engine attach points.



COLLET SYSTEM is used for missile-pylon attachment.

TWO HOUND DOG missiles ready for launch from a Boeing B-52G. Ailerons are preset and controls locked for a few seconds after release to fight the roll tendency caused by the B-52's wing air flow.

fuselage sections are fusion-welded by methods developed during the Navaho program. A shielded arc is used on special machines of which the fixture is an integral part. For longitudinal welds, the work is held static and the welding head is moved; for circumferential welds, the reverse is true.

Wing placement was governed by the location of the stiffener rings in the fuel tank. The wings have multiple spanwise spars and a stressed skin carrying the bending moment. The control surface assemblies are blind-riveted, with the exception of the fin leading edge, which is a sandwich construction.

The wings are neutral, so that they can be used interchangeably. The same holds true for the canard surfaces. Each wing is attached to the fuselage by seven bolts.

Astrotracker provides alignment

For aerodynamic control, a true rudder is provided on the fin and a pair of surfaces on the wings. The latter could be used as elevators but are predominantly used as ailerons. The canard system was chosen for pitch control because the location of the engine moves the CG fairly far aft, so that relatively little surface is needed to produce the desired moment. Another point in favor of canards was that they had worked well on the X-10.

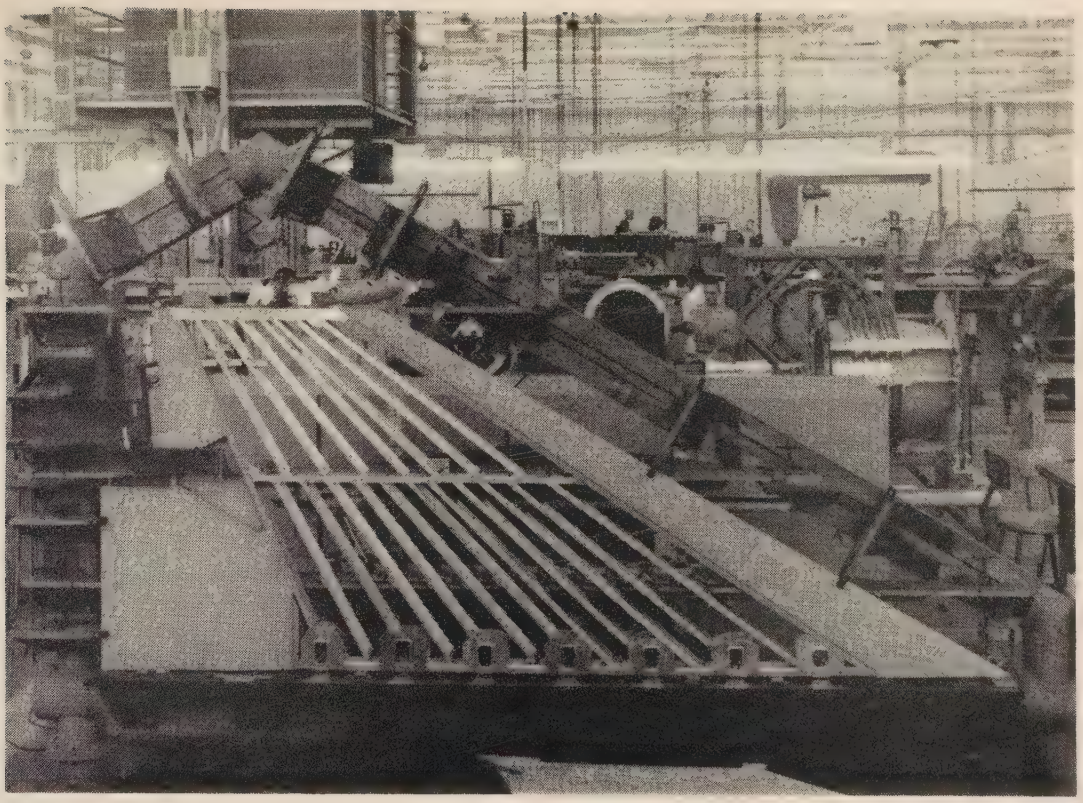
NAA designers explain that, fundamentally, the Hound Dog's control system is based on inputs of so many pounds per square foot to the missile's air data computer. This unit is part of a closed-loop servo system to the hydraulic actuators that's also coupled to the autonavigator. The latter is aligned during bomber cruise by an astro-tracker mounted in the pylon. The tracker continuously puts target data into the autonavigator to align the misile's stable platform up to the time of launch. Afer launch, the inertial system of the Hound Dog is completely self-contained.

Because of the Hound Dog's underslung nacelle, NAA points out, forces result that produce a roll tendency every time the missile turns and fight with fin and ailerons during each pitch maneuver. They are offset by the coupled autonavigator setup. Since the autonavigator knows the correct direction, it immediately returns a signal to get the missile back on course. Since there is lateral movement even during a dive the autonavigator can always be used to provide correction.

Ailerons are set before launch

The release of the Hound Dog from the B-52 posed another aerodynamic problem. The bomber's highly swept wing causes a peculiar air flow: air coming back from the bomber body tends to flow out spanwise along the wing. As a result, the missile on release tends to roll, becoming instantaneously unstable, instead of dropping away from the pylon. The missile's engine is running full blast at launch, but since it nevertheless needs a few moments to take effect, it can't be used to fight the roll tendency. NAA solved the problem by presetting the ailerons—only small aileron angle setting is necessary, engineers note. In addition, the control system is locked for a few seconds after launch.

The missile is attached to the pylon by a two-point collet system and sway braces. A slotted sleeve from the pylon fits over a mushroom-head fitting on the missile. A collar is forced down over the sleeve, closing the sleeve tangs over the head. The tangs are machined at just the proper angle to insure their release when



MULTI-SPAR construction of the wing is shown in this assembly line picture. Note doublers around the seven wing-to-fuselage attach points at bottom. The wing is made of 2024ST aluminum, as is most of the missile structure.

an explosive actuator is set off through a linkage system. Tests have proved that this system will release the missile at all times, NAA states.

To power the Hound Dog, NAA wanted a thoroughly proved engine that could be checked out on the ground and in captive flight. These requirements eliminated both rockets (because of ground test problems) and ramjets (because the B-52 can't fly fast enough to test them). NAA also points out that an APU would have been needed with either a rocket or a ramjet. A turborocket was considered, but rejected because of availability problems. In the end, NAA decided to use a "missilized" version of an aircraft turbojet. (A "missilized" turbine, which needs full power only during launch, runs hotter than a normal one.) The Pratt & Whitney Aircraft J52, with 7500 lb rated sea level thrust, was finally selected. Its installation was made as simple as possible by the deliberate omission of an afterburner. The first engine version installed in a Hound Dog was the J52-P-1; the production missile uses the -P-3.

Missile can take better engine

NAA chose a pod so that it would be able to use a future improved engine without redesigning the basic missile. The tail cone angle of exhaust can be controlled to eliminate the breakaway of air from the sidewalls, which could cause burbling and loss of thrust. The movable spike in the engine intake is a Marquardt-type design. Determined by the speed-pressure ratio, its position controls the inlet air for efficient engine operation at different altitudes. Reportedly, the J52 gives the missile speed capabilities slightly in excess of Mach 2.

Testing capabilities, NAA engineers emphasize, were built into the Hound Dog right from the start. In addition, two "house" missiles were produced strictly as the "playthings" of the engineering department and a facsimile "iron bird" was built to test the flight control and hydraulic systems. Thus when word comes back from the field of trouble in certain areas, the complaint can be immediately duplicated and studied.

Launch and cruise were simulated

With the Hound Dog's launch platform already in existence, NAA also could set up a program for captive test flight in which missile launch and cruise are simulated though the missile actually is never released. In these tests, the missile flies the bomber. On "launch", the missile is electrically disconnected from the B-52, but a hookup from the missile's flight control system sends information to a lateral-deviation meter that shows the pilot how to fly the plane. All missile systems are running on power from the missile generator, powered in turn by the missile engine, so that transients liable to occur during launch can be checked.

NAA decided early in the Hound Dog program that a combined ground and simulated flight checkout was needed—it couldn't take the slightest chance of the missile's blowing up while installed on a B-52. A flight attitude positioner therefore had to be developed for simulated flight testing. A missile and its pylon is at-

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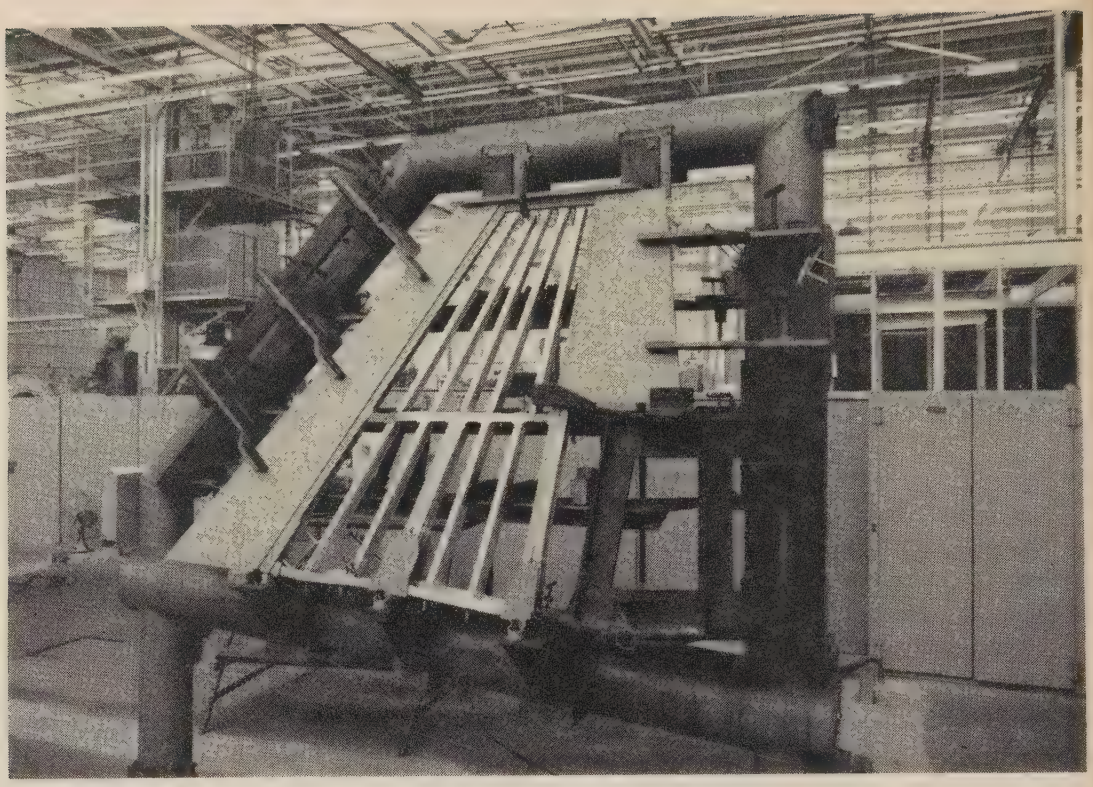


VERTICAL TAIL of the North American GAM-77 Hound Dog missile in its assembly jig. The fin nose structure is a honeycomb-core design. The missile's other control surfaces are blind-riveted.

tached to the positioner, which then is given a command such as "dive". The positioner then simulates this maneuver, with the missile engine running at some predetermined below-maximum level that provides just enough power to keep all systems running. This setup, NAA states, avoids the transients that would occur in conventional checkout rigs. Engineers therefore can check inputs and responses as well as observe missile reaction. The present positioner is semi-automatic, but work is proceeding on a completely automatic design.

GSE design was a major problem

Every R&D Hound Dog is checked out on a positioner before delivery to engineering. Engineering then makes five simulated flight runs on its own positioner before O.K.ing the missile for shipment. At the field receiving station, another positioner check is made. For the present R&D missiles, 3-6 captive flights are then required before launch.

Preliminary designers point out that developing the Hound Dog's ground support equipment was more of a problem than the design of the missile itself. NAA naturally tried to keep the GSE as simple as possible. However, its studies showed that you couldn't go too far in that direction if USAF was to get a missile that itself is simple and reliable, company engineers explain. In all, 160 pieces of GSE were designed for the R&D Hound Dog. Not all of these will be needed for production missile, since some consoles check out only test instrumentation gear.

The Hound Dog control panel in the Boeing B-52G measures about 30x12 in. A crash effort was needed early in the program—before the missile itself was fully designed—to tell Boeing what wires to install between this panel and the pylon. A measure of the close cooperation between Boeing and NAA, it's pointed out, is given by the fact that the eventual mating of plane and the missile went off without a hitch.

A prime factor for NAA's success in the Hound Dog competition, company engineers believe, was that NAA planned to run the program on a project basis. Under this setup, engineering manager Martin Boe and weapons system manager Dale Myers have a definite line of authority for expediting decisions and overall control through all design phases including flight test.

Long-distance control of tests

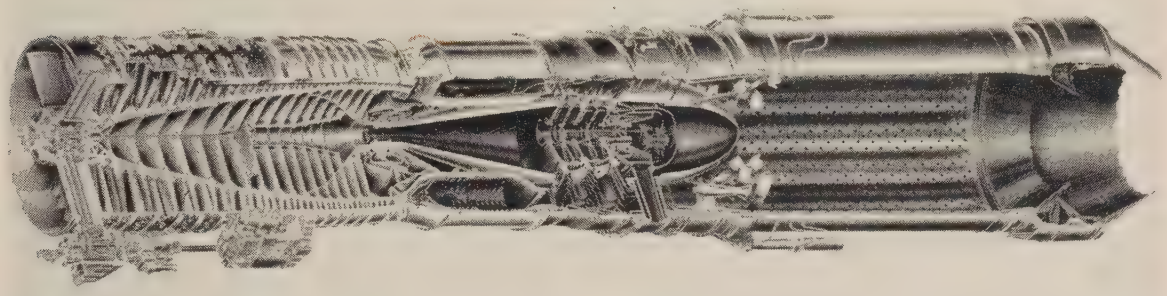
As part of its project approach, NAA set up a communications room at its Downey, Calif., plant that's connected directly to the test bases every time a Hound Dog launch is planned. For any test flight, data is sent directly to this room, and a plot of the missile's prelaunch progress is made there. If trouble crops up, the communications room radios, say, Eglin AFB, Fla., and asks for more details. Test engineers in the B-52 or on the ground will tell the communications room, "Gage X reads so and so. Shall we go on?" The program manager himself in the communications room then can say immediately "go" or "abort".

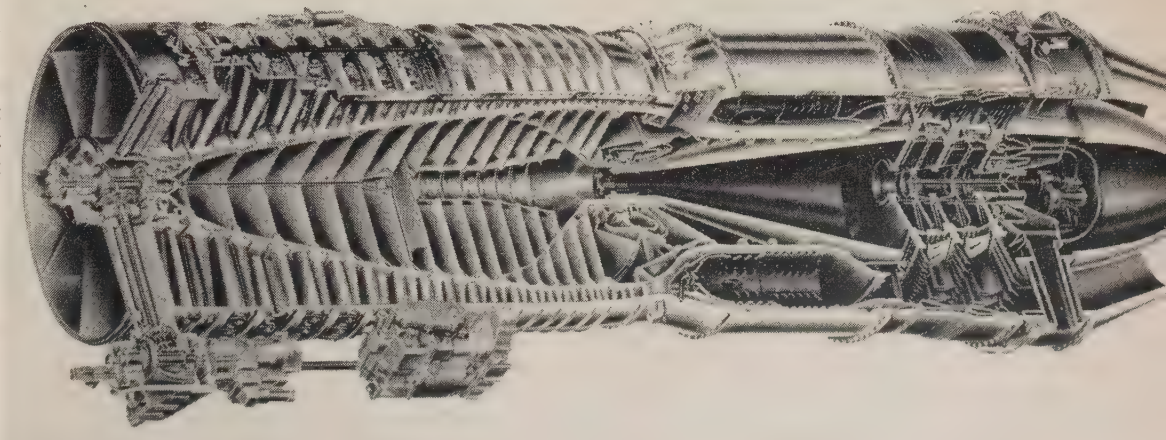
The Hound Dog is about 43 ft long. The height from the "canoe" (an aerodynamic fairing over the engine accessory installation) under the nacelle to the top of the fuselage is estimated to be about 61 in. The missile's estimated range is about 350 nm.—End

Design details of J79 turbojet

by Randolph Hawthorne
Editor

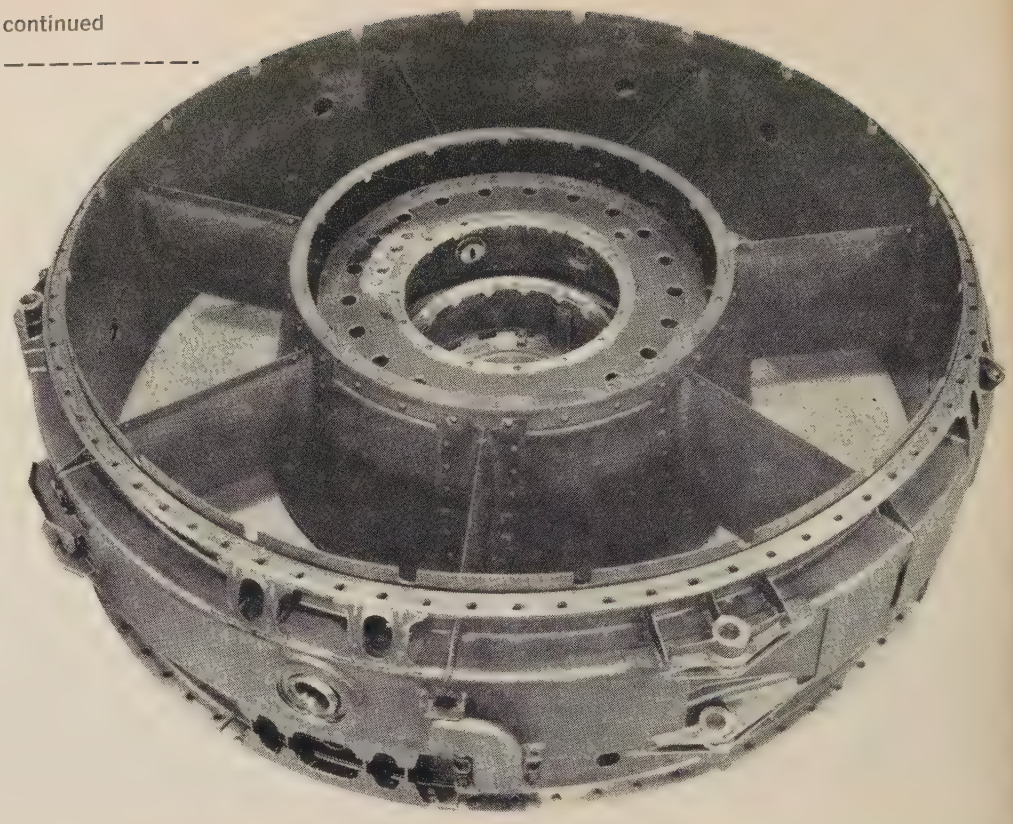
HIGH THRUST, low weight, good cruise economy, and comparatively small size make the 15,000-lb thrust class J79 a versatile engine. It was developed in less than four years by General Electric Co., Aircraft Gas Turbine Div., Cincinnati 15, Ohio. It reached the production stage after undergoing more than 12,000 hours of factory, simulated altitude, and flight testing, most of it in 1956. A major factor in keeping weight down is the use of variable stators. These, in a mechanically simplified way and with far less weight, do the same thing that the dual rotor does in other engines. Other outstanding features of the J79 include its high compressor pressure ratio of 12:1, which insures good subsonic fuel economy and, combined with the variable stators, gives top performance at Mach 2. GE made wide use of fabricated steel alloys throughout the structural and hot static parts. These replaced castings and saved more weight, while increasing durability. Another weight saver is the "conical" turbine shaft. It transmits up to 70,000 hp at maximum rpm and weighs much less than equivalent cylindrical shafts of the same torsional strength. The J79-GE-3A's frame is 32 in. in diameter. Length is 204 in., and weight is in the same class as the J47's—3200 lb. Write in No. 56 on Reader Service Card for more information.





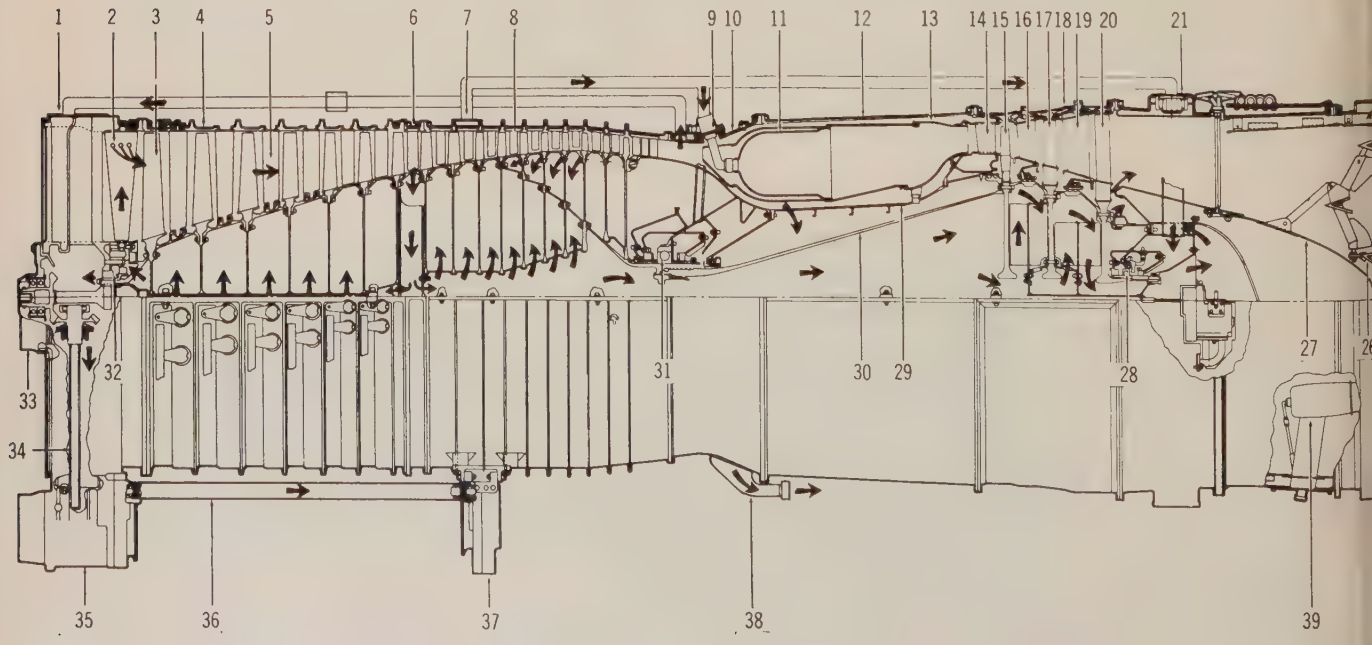
J79 CUTAWAY showing internal layout of components. Three bulkhead sections are used as support and alignment members: front frame, compressor rear frame, and turbine frame.

CJ-805 COMMERCIAL engine is generally the same in arrangement except it has no afterburner.

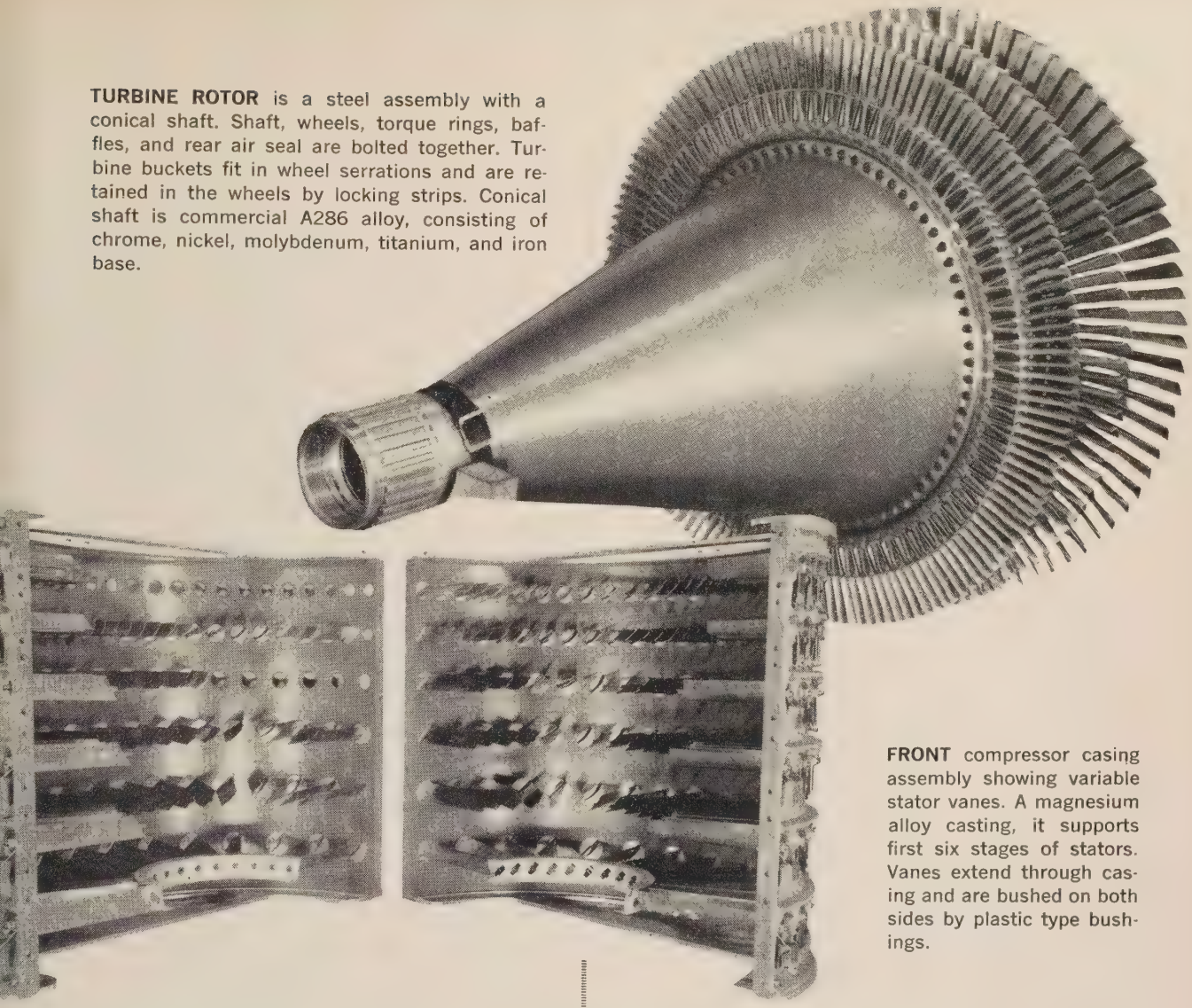


TURBINE FRAME departs from previous engine designs in being placed at an engine point about that of the exhaust cone in standard reheat design. Thus it operates at high exhaust gas temperatures. It comprises an outer casing, inner diffuser baffle and several other sheet metal shields with seven struts. These serve to introduce or remove oil supplies and scavenges from the engine.

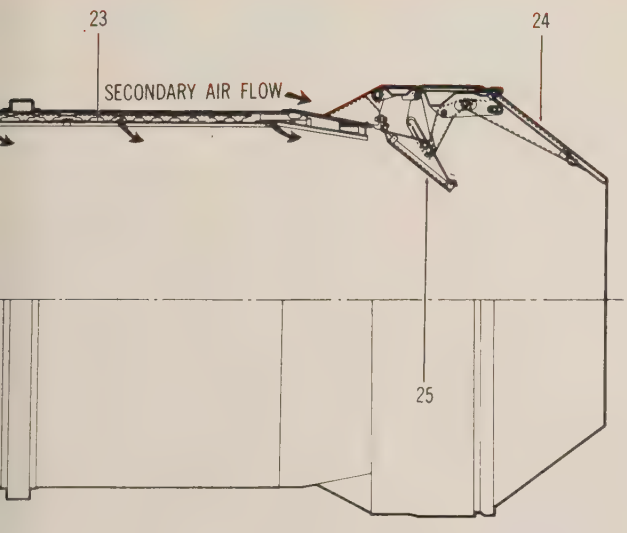
AIR DISTRIBUTION and parts of General Electric's 15,000-lb thrust class J79 gas turbine engine: (1) compressor front frame, (2) inlet guide vanes, (3) rotor blades, (4) casing, (5) stator blades, (6) intermediate casing, (7) ninth-stage manifold, (8) rear casing, (9) fuel nozzle, (10) compressor rear frame, (11) combustion liner, (12) outer combustion casing, (13) transition liner, (14) first-stage turbine nozzle, (15) first-stage buckets, (16) second-stage nozzle, (17) second-stage buckets, (18) turbine casing, (19) third-stage nozzle, (20) third-stage buckets, (21) turbine frame, (22) tailpipe assembly, (23) liner, (24) secondary nozzle flap, (25) primary nozzle flap, (26) flameholder, (27) rear inner cone, (28) No. 3 bearing, (29) inner combustion casing, (30) turbine shaft, (31) No. 2 bearing, (33) front gearbox, (34) radial drive shaft, (35) transfer gearbox, (36) horizontal drive shaft, (37) rear gearbox, (38) 17th-stage leakage port, (39) pilot burner.

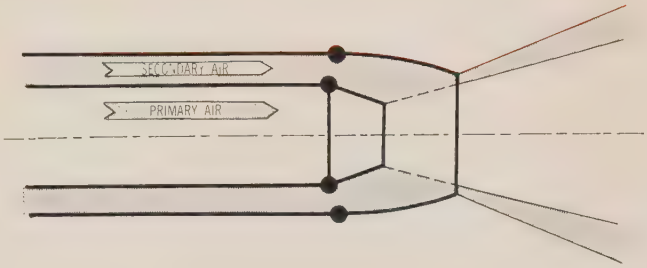


TURBINE ROTOR is a steel assembly with a conical shaft. Shaft, wheels, torque rings, baffles, and rear air seal are bolted together. Turbine buckets fit in wheel serrations and are retained in the wheels by locking strips. Conical shaft is commercial A286 alloy, consisting of chrome, nickel, molybdenum, titanium, and iron base.

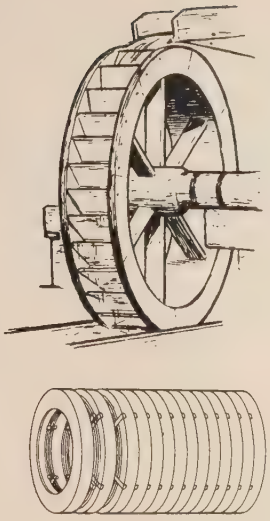


FRONT compressor casing assembly showing variable stator vanes. A magnesium alloy casting, it supports first six stages of stators. Vanes extend through casing and are bushed on both sides by plastic type bushings.





EXHAUST NOZZLE operation: nozzle assembly consists of afterburner or primary nozzle, and secondary nozzle or shroud, each equipped with movable fingers. Shroud moves aft as fingers open. Airframe-supplied secondary air provides aerodynamic cushion against which expanding primary gas flow acts to effect the diverging section of the converging-diverging nozzle.



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GRUMMAN YAO-1 Mohawk Army observation plane was designed for short takeoff and landing, operation from rough fields, maximum visibility for the crew, and good low speed control.

Grumman Mohawk

features short-field performance

It's news these days when a company in the aerospace industry claims to have scored a success because its engineers were playing it safe. But that's really the story behind the Mohawk observation plane—the intelligent application of tried and proven design techniques.

by Homer U. Tsakis, Engineering Staff, Grumman Aircraft Engineering Corp.*

IN DESIGNING the Army's YAO-1 Mohawk observation plane, Grumman's prime goal naturally was to come up with a craft well suited to tactical recon missions. In addition, the Mohawk was designed for operation from unimproved areas—with its very high thrust-takeoff-weight ratio of 0.615 and its proven conventional high lift devices, it needs only about 400 ft for takeoff or landing.

The Mohawk can also carry 1500 lb of supplies in two containers for parachute drops or, alternatively, two 150-gal drop tanks that give it a maximum range of 1450 nm.

The Mohawk is the result of a design contest announced by the Army and BuAer in late 1956. An important reason for Grumman's success in this contest was that its proposed design relied on the refine-

more on next page

* Grumman Aircraft Engineering Corp., Bethpage, N.Y.

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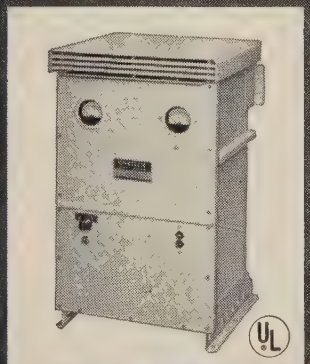

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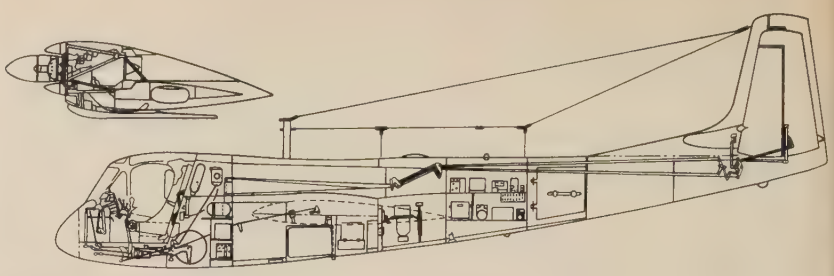

INBOARD profile of the Grumman Mohawk.

ment of a conventional configuration. This approach cut down sharply on development time—five months after the award of the first contract, virtually all designs were firmed up and a full-size mockup had been built.

Only one major configurational change had to be made in the early design stage. The original Mohawk configuration called for a single vertical stabilizer and rudder with a high horizontal stabilizer. Wind tunnel tests of a 1/7-scale model showed that, with this design, a powered trimmer would be needed for single-engine flight. To avoid this complication, Grumman changed to a triple tail with a low horizontal stabilizer.

The configuration of the Mohawk largely is the direct result of the design requirements:

- short takeoff and landing,
- maximum field of vision for the two-man crew,
- operation from unimproved areas,
- good low speed control,
- drop tank and supply pod capabilities,

more on page 68

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And, of course, the name USS National is backed by the world's largest and most experienced manufacturer of seamless tubing—National Tube! The production of USS National Seamless Tubing, from ore to finished product, is entirely controlled by one organization. There is no divided responsibility. Every foot, every length, is made under the careful supervision of skilled men with years of tubemaking experience. For more than 60 years, USS National Seamless Tubing has been first with men who want the best in mechanical tubing.

You'll find USS National Seamless Tubing available at select National Tube Distributors throughout the country. These distributors are strategically located and expertly trained in solving all types of tubing problems. Here, you can choose from a complete range of sizes and stocks. If you'd like to find out how USS National Seamless Tubing can be most effectively applied to your designs, contact your nearest USS National Distributor . . . *soon!*

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United States Steel Export Company, New York

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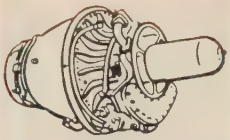
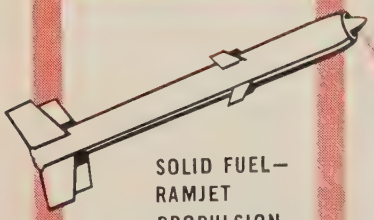
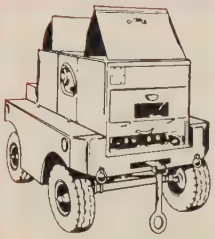


TURBINE PROPULSION



SOLID FUEL—
RAMJET
PROPULSION



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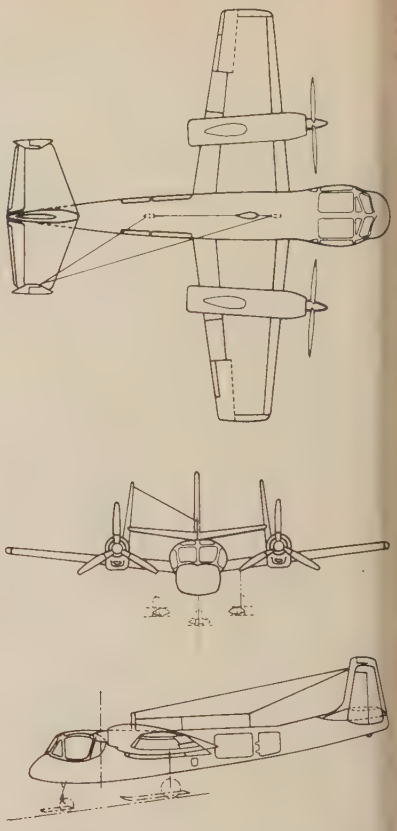


TRIPLE TAIL, large cockpit placed well forward, and twin turboprops in midwing location give the Mohawk its distinctive appearance.

● room for photographic and electronic equipment.

Another important design factor was the weight limit of 5000 lb empty on newly procured Army aircraft. Because the Mohawk was designed to Marine Corps as well as Army specs, this limitation actually was waived—the empty weight of the plane is 7722 lb.

The *Table* gives details on both the configuration and the performance of the Mohawk. Despite the great emphasis on low altitude and speed performance, the plane also has a respectable top speed (275 knots) and service ceiling (32,500 ft).

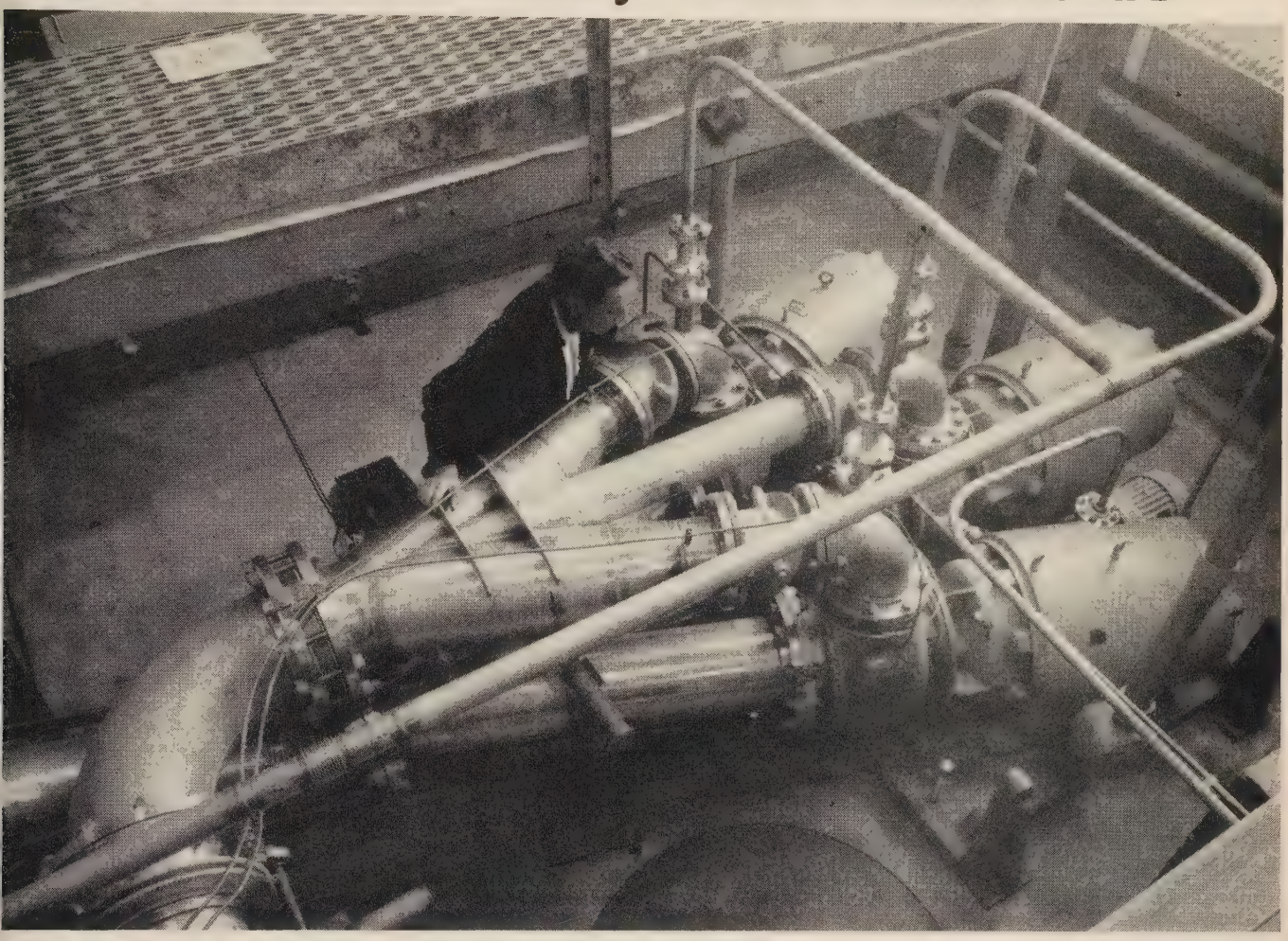
The Mohawk is powered by two lightweight Lycoming T53-L-3 engines on its upper wing surfaces. Each T53 produces 960 shp and 100 lb thrust at takeoff.

A conventional tricycle landing gear is used, with low pressure tires for operation from unimproved strips. For operation from snow, ice, or mud, skis can quickly be installed that retract with the gear and also don't interfere with opera-

more on page 70

FIRST

ICBM Liquid Oxygen Pump Loading System Successfully Tested at Edwards AFB



Carter Designed 6,000 GPM System Simplifies Propellant Loading

Developed on Air Force contract and independently tested by Convair Astronautics at Edwards Air Force Base, this first high flow liquid oxygen pump loading system was designed to replace present complex pressure loading systems. Quadrupling previous capacity limits, the new system incorporates a unique combination of single and multiple fixed speed pumps to accomplish the required control without complex low efficiency variable speed devices. The Carter system includes a control center incorporating high reliability standard components which automatically sequences system cool-down, rapid fill, fine fill, and topping functions in response to signals from the missile system. No human attention is required after the loading is started.

Unique fail safe feature assures continuous reliability. In case of any malfunction in either of the main pumps, Pump A automatically comes on the line at 1760 RPM to prevent aborting the mission.

The system consists of four separate pumps operating as follows:

Operation	Pumps On	Speed	Flow-Rate
Cool-down	A	870 RPM	Variable
Rapid Fill	B & C	1760 RPM	6000 GPM
Fine Fill	A	1170 RPM	700 GPM
Topping	D	3500 RPM	27 GPM

Write for further information or phone LIberty 8-3421

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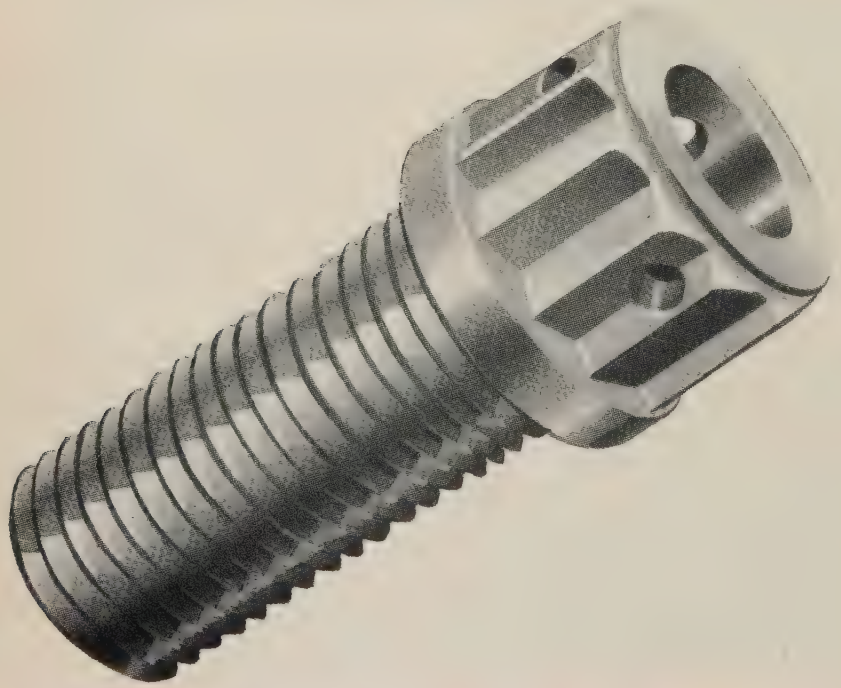

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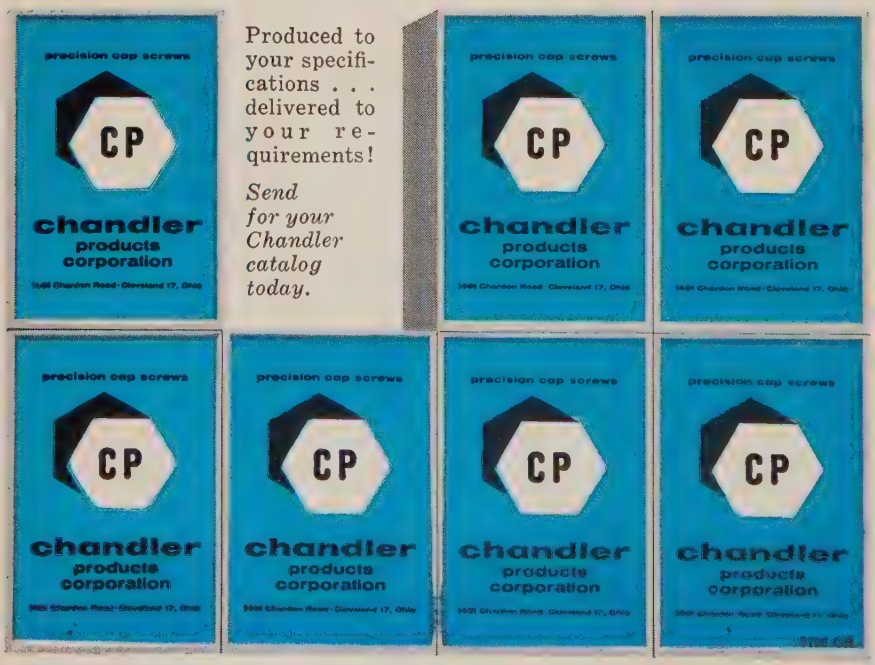

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Grumman YAO-1 Mohawk

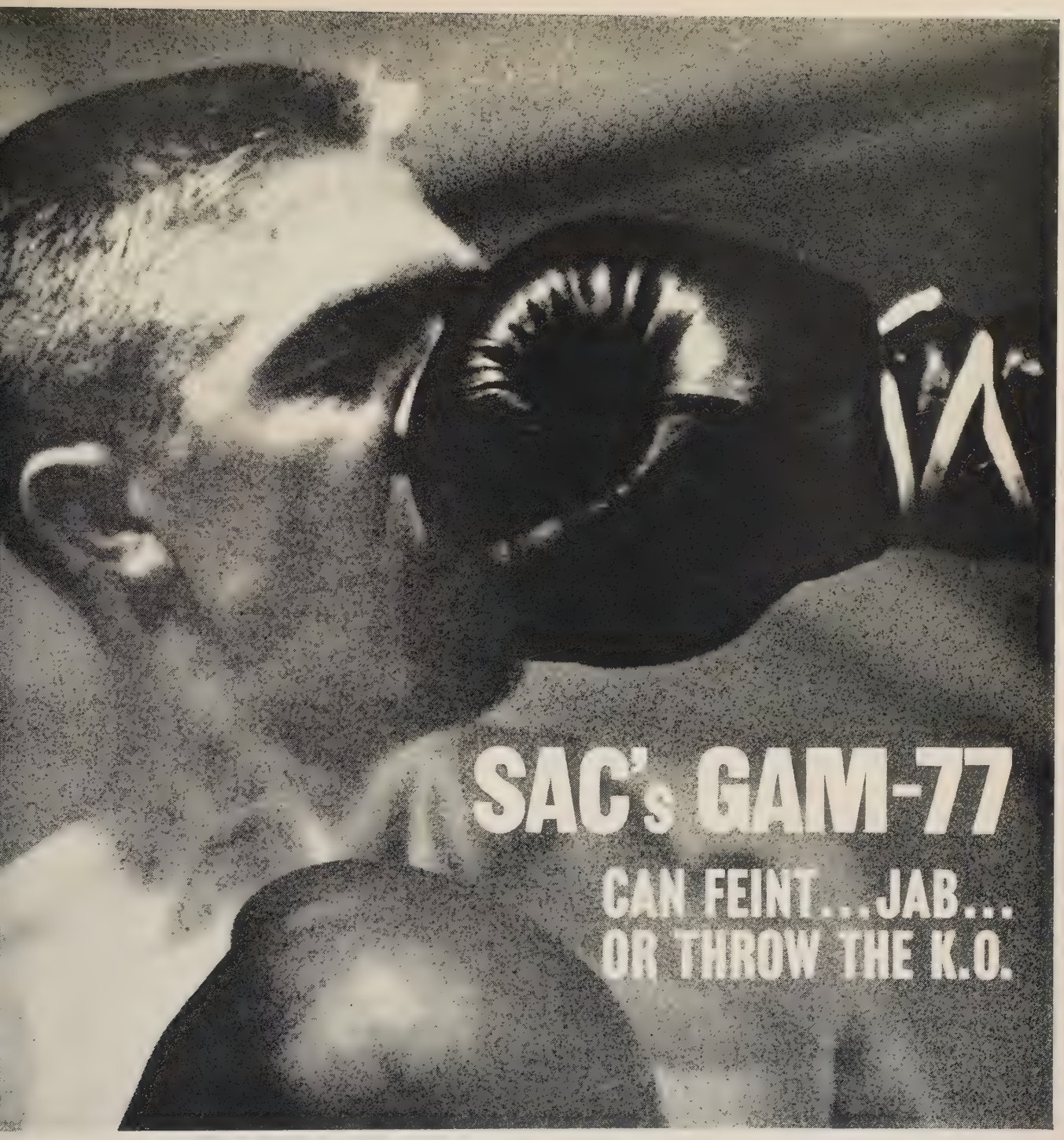
Specifications	
Wing span	42 ft
Overall length	41 ft
Tail height	12 ft 8 in.
Wing area	330 sq ft
Aspect ratio	5.35
Takeoff weight	10,088 lb
Empty weight	7722 lb
Fuel weight (JP-4)	1666 lb
Performance	
Maximum speed (5000 ft, military power, level flight	275 knots
Stall speed (sea level, landing configuration, 10 per cent normal rated power)	55 knots
Takeoff distance (over 50-ft obstacle)	655 ft
Landing distance (over 50-ft obstacle)	776 ft
Service ceiling (military power, takeoff weight less 20 per cent fuel)	32,500 ft
Rate of climb (sea level, takeoff weight less 20 per cent fuel)	
Two engines (normal rated power)	3000 fpm
One engine (military power)	1050 fpm
Endurance, (200 knots, 5000 ft)	2 hr
Ferry mission range (two 150-gal external tanks)	1450 nm

tion from paved runways.

The Mohawk cockpit was located and laid out almost exclusively for maximum visibility. The large, slightly sloping windshield is virtually continuous with the slope of the truncated nose. Together with the bubble side panels and the transparent, jettisonable overhead hatches it gives a "greenhouse" effect.

Pilot and observer sit side by side. The instrument panel is sloped forward 15 deg to eliminate parallax and bezel interference and is designed for solo flight from either side. The crew is protected from ground fire by the one-inch-thick windshield, which is bullet-proofed on both sides, ½-in.-thick aluminum flooring throughout the cockpit, ¼-in.-thick aluminum side panels, and removable flak curtains on the fore and aft cockpit bulkheads. Martin-Baker ejection seats are provided for bailing out at virtually any point within the flight envelope.

more on page 74



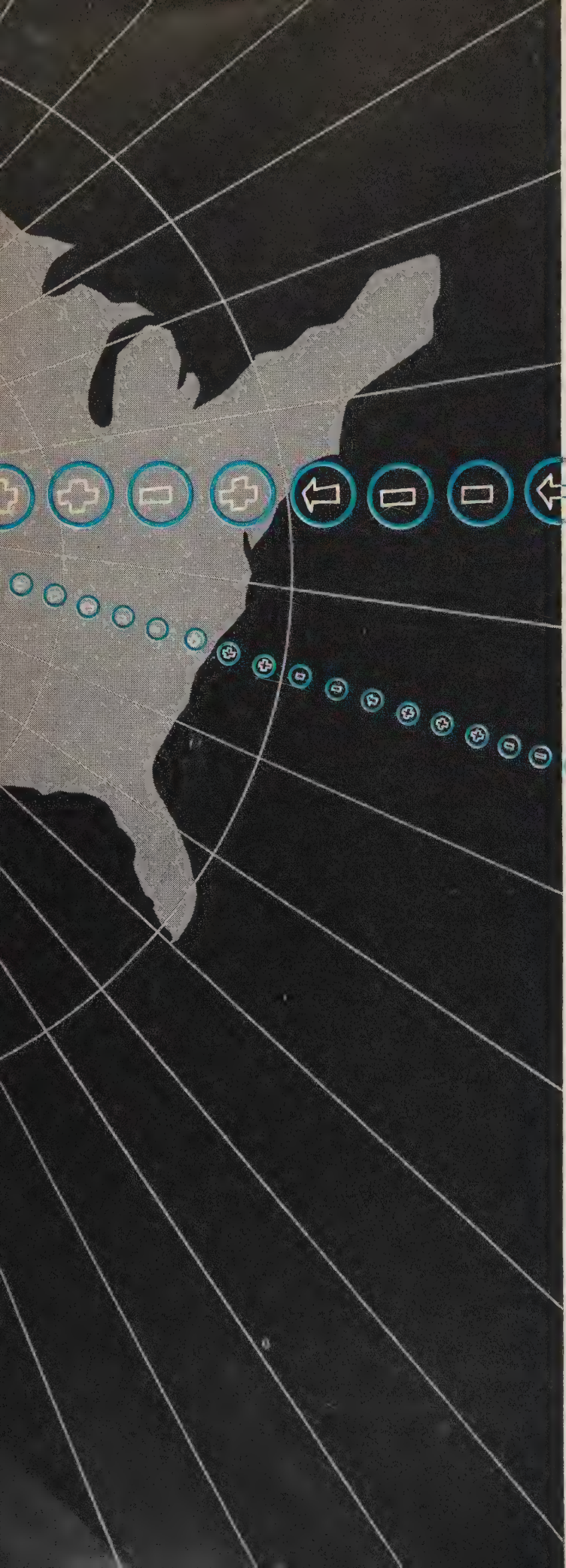
GAM-77 HOUND DOG air-to-surface missiles give SAC's B-52G intercontinental bombers the versatility of a champion boxer. Even while the aircraft carrying the GAM-77 missiles is airborne, a new target can be selected. Then reaching out at supersonic speeds after launch, the GAM-77's can flatten opposition for the bomber to deliver its own Sunday punch... or independently destroy the primary target. These jet-powered missiles vastly increase the striking power of the giant Boeing B-52... give it a triple-punch capability.

Guided by a self-contained inertial autonavigator—set before launch by the B-52's crew—the GAM-77 can't be jammed, can't be decoyed. The GAM-77 Hound Dog was designed and is being produced for the USAF by the Missile Division of North American Aviation.

MISSILE DIVISION

NORTH AMERICAN AVIATION, INC.

Downey, California



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Molded Harnesses for Missiles

Powered by the tremendous thrust of a rocket engine produced by the Reaction Motors Division of Thiokol Chemical Corporation, the North American X-15 —the first manned space vehicle—will exceed speeds of 3600 mph and will penetrate more than 100 miles into space. Revere Molded Harnesses, developed in conjunction with Reaction Motors' engineers, will supply the vital electrical interconnections for this mighty powerplant.

The completely sealed and protected harnesses exceed rigid specifications and provide:

1. Continuous operation from −70°F to +275°F
2. Ten minute operation at +500°F without damage
3. Protection against the occurrence of corona; operation at 100,000 feet without corona
4. Environmental protection against H_2O_2, anhydrous ammonia, liquid oxygen and 100% humidity

Harnesses for the X-15 engine are another example of the many types of specially designed Revere harnesses. Electrical interconnections for airborne and ground applications, thermocouple harnesses for heat measurement, molded harnesses for complete environmental protection—all are custom engineered to meet specific requirements.

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VHF, AN/ARC-39 for HF) and an ICS unit (basically an AN/ARC-14 type); the AN/ARN-21 tactical navigator, AN/ARN-32 marker beacon receiver, and AN/ARN-59 (ARC 21A) LF direction finder for navigation; and the AN/APX-6B transponder identification system and AN/APA-89 (SIF) coder group for identification.

The photographic installation uses a remote-control system for operation of a camera located in the fuselage midsection. The camera can be either a KA-30 with a three-, six-, or twelve-inch lens or a KB-10 with a three-inch lens. By flipping a control panel selector switch, the camera mount can be rotated to left and right positions 15 and 30 deg from the vertical. Space has also been allowed for an AN/APN-78 Doppler navigation system, a Sperry autopilot, a TV camera with recording equipment, and forward-looking radar.

All flight control surfaces are manually actuated. The flaps, speed brakes, and slats are hydraulically positioned. The directional and longitudinal control systems consist of push rods, bellcranks, and cables in tension. To make the plane less vulnerable, there are two independent longitudinal control systems, running along opposite sides of the fuselage and connected only at the control sticks and the aftmost bellcranks. For directional control trim, a tab on the center rudder is operated by a manual cable-and-drum system, which includes a gust lock for blocking the throttles in the cockpit. For lateral trim control, there is a tab on the right aileron. The same kind of system is used for actuation as with the directional trim tab.

The control sticks are mechanically connected to aileron spring tabs through a push rod system arranged to provide a direct mechanical connection between the two ailerons. Auxiliary aileron surfaces—between the normal ailerons and the nacelles—give additional control in single-engine flight. They are driven by an irreversible power system that is also connected to the normal ailerons when the flaps are extended.

Full-length flaps and slats increase the wing lift at low speed. The slats are installed in four mechanically interconnected sections (two on each side inboard and out-

more on page 76

AERONCA
air transportable shelters

MISSILE SUPPORT SYSTEMS

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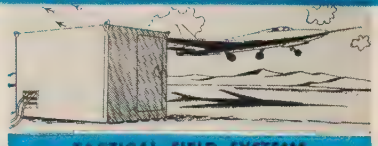

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lightweight high-strength shelters feature new design and versatility to meet global requirements

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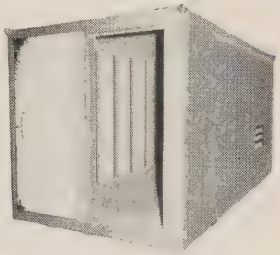
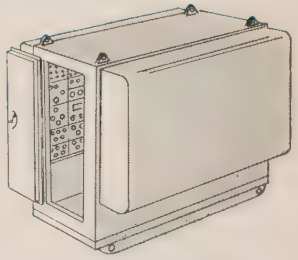


MODULAR SHELTER
Model ASC 10-14 is used in the ground support complex of a current operational missile system.



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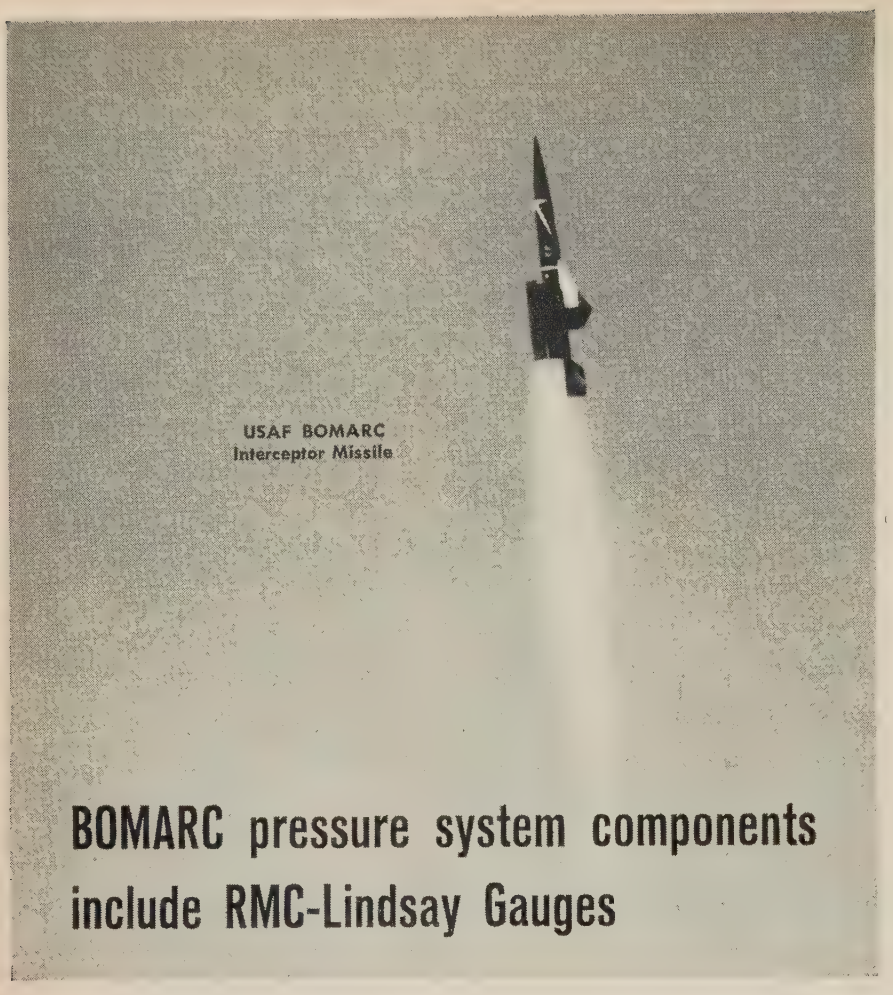

BOMARC pressure system components include RMC-Lindsay Gauges

The Boeing Bomarc, a true "push-button weapon," automatically seeks out and destroys its target. In such a weapon there can be no compromise in the performance requirements for its mechanical and electronic components.

Among these components, RMC-Lindsay "gearless" pressure gauges are employed on two Bomarc assemblies—the ram jet full pressure system and the nose air pressurization system.

RMC-Lindsay gauges withstand shock tests of 100 G's. They are checked for accuracy in vibration tests ranging from 10 to 2,000 cps at 35 G's and at ambient temperatures from −65° F. to +430° F. There is no linkage, no gear train—the indicating pointer is attached directly to the end of the helical bourdon coil. Qualified under MIL-E-5272.

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RMC
LINDSAY PRESSURE GAUGES

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board of the nacelles) and moved on 10 sets of tracks by hydraulically driven mechanical linkages. Their control is integral with that of the flaps. However, they are operated through their full range of motion while the flaps travel only from zero to 25 deg.

The flap system consists of special flap surfaces from the fuselage to the outboard edges of the nacelle fairings and the auxiliary ailerons. The three flap positions are zero, 25, and 45 deg.

The speed brakes on the aft section of the fuselage make it easier for the Mohawk to "drop into" restricted landing areas. The two brakes can be extended or retracted in three seconds. They are actuated by separate hydraulic cylinders whose operation is synchronized by a pressure regulator.

The Mohawk's engine nacelles are designed for easy access to the engines and their controls and accessories. If necessary, the entire powerplant package (including prop and engine mounts with vibration isolators) can be removed as a unit.

The first nine Mohawks will have both an air turbine starter and a starter-generator. It is expected that further improvement of the starter-generator will make it possible to eliminate the air turbine starter on the production aircraft.

The fuel systems for the two engines are closely integrated. Two submerged centrifugal pumps in the 256-gal main fuel tank charge the main fuel line feeding both engines. These pumps are located at the fore and aft ends of the tank, so that fuel will flow at any aircraft attitude and fuel level. Each pump can meet the combined maximum requirement of both engines.

The Mohawk's airframe is conventional and simple. The basically semi-monocoque fuselage is broken down into a forward (cockpit) section, a midsection (integral with the wing center section), an aft section, and the empennage. The outer wing panels, which are readily removable from the center section, include the nacelles.

Most of the manufacturing techniques used on the Mohawk are straightforward. In some cases, though, new methods were adopted that showed definite advantages in terms of strength, weight, or production time. Foremost among these techniques is chemical milling, chosen for the entire upper and lower wing skins.—End

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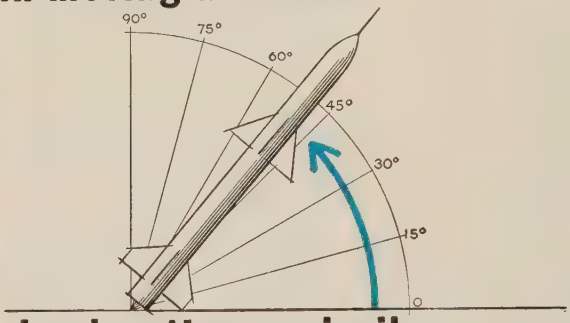
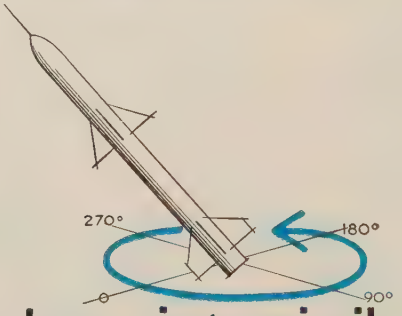


...in elevating a missile



...in traversing a missile

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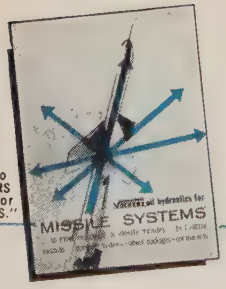

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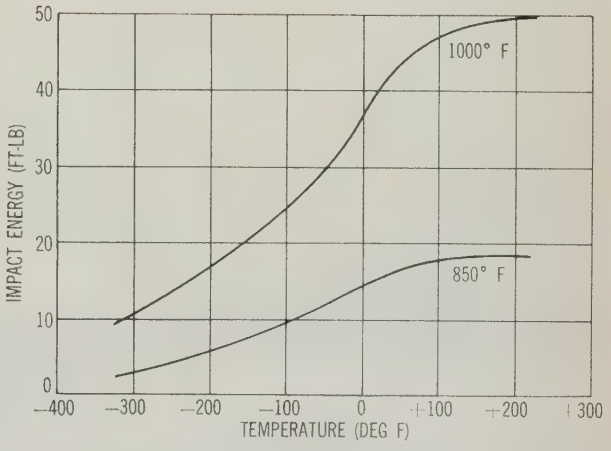
Designing with AM-350 and AM-355 high strength stainless

In the relatively short time since their introduction, the AM-350 and AM-355 stainless steels have helped to meet quite a few of the design demands of advanced aerospace structures and components. This article reviews the state of the art in these key alloys and presents previously unpublished data.

by T. H. McCunn, Research Metallurgist,
Research & Development Laboratories,
Allegheny Ludlum Steel Corp.*



CHARPY V-NOTCH impact strength of AM-355 bar for two different tempers.

THE semi-automatic "precipitation-hardening" stainless steels AM-350 and AM-355 were developed by Allegheny Ludlum Steel mainly for use in aircraft and missiles.[2] They combine good formability in the annealed condition with high strength and ductility and good corrosion and oxidation resistance up to about 900 deg F in the hardened condition.

Both grades are obtainable in a wide variety of forms, like sheet, strip, foil, bar, wire, and tubing. AM-355 is also available as plate, forgings, and forging billets. A slightly modified composition is used for castings.

The compositions of AM-350 and AM-355 are very similar (*Table VI*). They are balanced so that the alloys are austenitic as annealed and martensitic as hardened. In the annealed condition, their formability approaches that of the copper-nickel austenitic stainless steels. After hardening, they have the high strength of the martensitic steels. Corrosion resistance is comparable to that of the conventional austenitic stainless steels.

Heat treatments depend on the desired combination of mechanical properties. All, however, follow the basic principle that the extent of austenite-to-martensite transformation, or austenite stability, is controlled by carbide precipitation. When the alloys are rapidly cooled from 1875 deg F, carbides are in solution and the austenite has its maximum stability. Sheet and strip therefore are supplied in the annealed condition for best formability. (In the annealed condition, the alloys are less stable than Type 301, the least stable of the Cr-Ni austenitic steels.)

more on next page

(1) Research & Development Laboratories, Allegheny Ludlum Steel Corp., Brackenridge, Pa.
(2) These alloys are also produced under license by Carpenter Steel, Crucible Steel, Universal Cyclops Steel, and Vanadium-Alloys Steel.

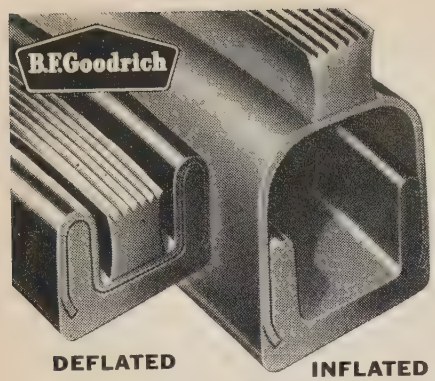


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Table I

Tensile Properties of SCT AM-355 Bar*

Test Temperature (deg F)	0.02% Yield Strength (psi)	0.2% Yield Strength (psi)	Tensile Strength (psi)	Elongation (per cent)	Area Reduction (per cent)
		Tempered at 850 Deg F			
room	142,000	182,000	216,000	19	38
400	123,000	162,000	207,000	16	45
600	111,000	152,000	209,000	12	36
800	97,000	138,000	198,000	11	36
1000	66,000	97,000	144,000	15	55
		Tempered at 1000 Deg F			
room	147,000	171,000	185,000	19	57
400	133,000	155,000	166,000	17	59
600	121,000	143,000	159,000	14	50
800	108,000	127,000	143,000	16	54
1000	72,000	97,000	115,000	18	64

* 1750-deg F water quench, three hours at —100 deg F, and three hours at tempering temperature.

Table II

Stress-Rupture Properties of AM-355

Test Temperature (deg F)	Stress for Fracture (psi) In 10 Hr	In 100 Hr	In 1000 Hr
	CRT[1]		
800	191,000	190,000	182,000
900	158,000	135,000	116,000
1000	110,000	85,000	65,000
	SCCRT[2]		
800	250,000	244,000	225,000
900	185,000	127,000	86,000

(1) On 0.056 in. gage. (2) On 0.018 in. gage.

When the annealed material is reheated in the 1200-1800-deg F range, the stability of the austenite is decreased by the precipitation of the chromium carbides. The austenite transforms almost completely to martensite on cooling to a sufficiently low temperature. The alloy can then be tempered much like the conventional martensite steels.

Two heat treatments are recommended for hardening:

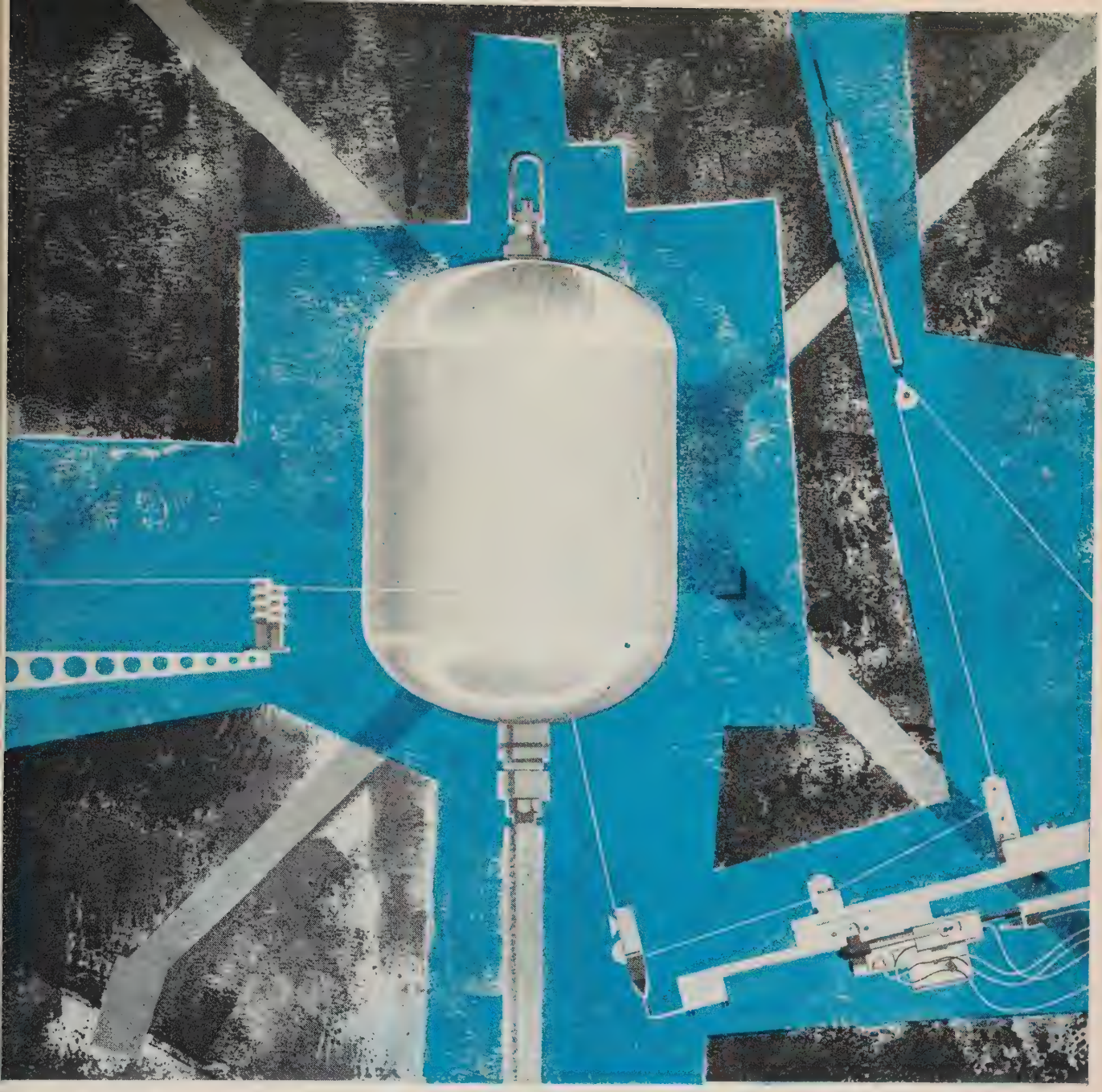
- To produce the *SCT* condition, reanneal at 1700-1750 deg F, cool to —100 deg F, and temper.
- To produce the *DA*, or double-aged, condition, heat at 1375 deg F, cooling to room temperature and temper.

In both cases, tempering at 850 deg F results in maximum strength; tempering at 1000 deg F gives lower strength, but higher ductility and impact properties.

Since machinability rather than formability is usually the major requirement for bars and forgings, these forms are generally supplied in the "equalized and overtempered" heat-treated condition. This condition is produced by heating in the 1375-1475-deg F range for three hours, cooling to room temperature, and tempering in the 1050-1100-deg F range for three hours.

Microstructurally, the material can be described as overtempered martensite with a hardness of about R_C 38. This is more than the con-

more on page 84



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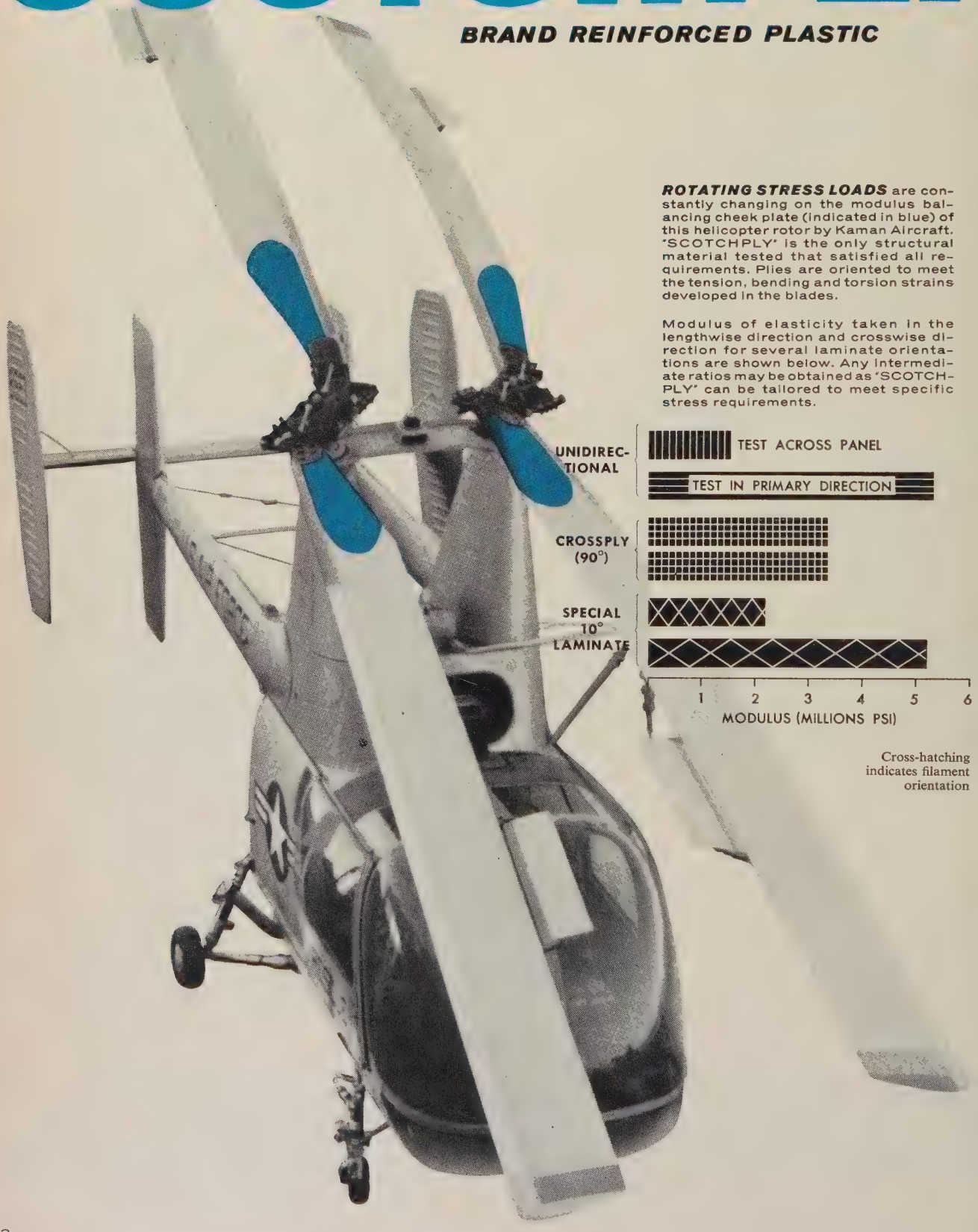

ROTATING STRESS LOADS are constantly changing on the modulus balancing cheek plate (indicated in blue) of this helicopter rotor by Kaman Aircraft. "SCOTCHPLY" is the only structural material tested that satisfied all requirements. Plies are oriented to meet the tension, bending and torsion strains developed in the blades.

Modulus of elasticity taken in the lengthwise direction and crosswise direction for several laminate orientations are shown below. Any intermediate ratios may be obtained as "SCOTCHPLY" can be tailored to meet specific stress requirements.

Cross-hatching indicates filament orientation

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See Sweets Product Design File insert 2a.
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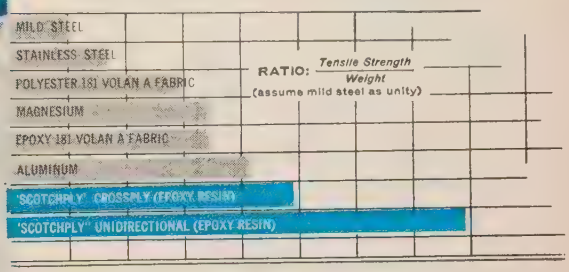
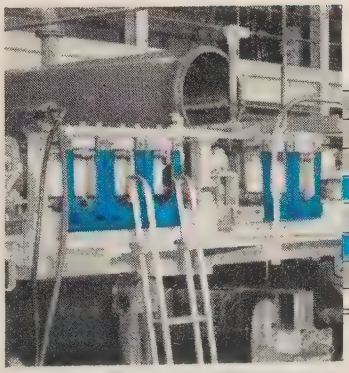
Tensile strength-weight ratios





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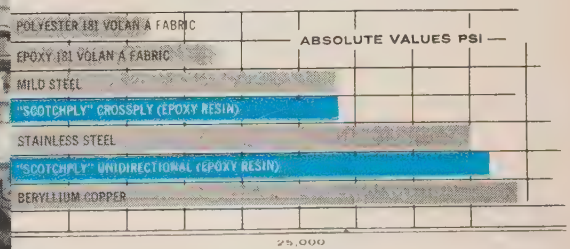

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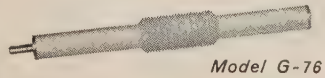

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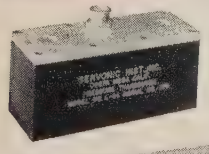

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Table III

Density and Typical Transverse Tensile Properties of AM-350 and AM-355 Sheet and Strip

Condition	0.2% Yield Strength (psi)	Tensile Strength (psi)	Elongation in 2 in. (per cent)	Density (lb cu in.)
	AM-350			
1950 deg F anneal	60,000	160,000	40	0.286
SCT[1]	175,000	205,000	12	0.282
DA[2]	155,000	180,000	12	
CRT[3]	140,000	185,000	25	
	AM-355			
1875 deg F anneal	60,000	185,000	30	2860.
SCT[1]	185,000	220,000	12	0.281
DA[2]	160,000	190,000	12	
CRT	195,000	235,000	16	0.284
SCCRT	280,000	290,000	2.5	0.2805
XH	330,000	350,000	approx. 0.5	

(1) 1710-deg F air-cooling, three hours at —100 deg F, three hours at 850 deg F. (2) Three hours at 1375 deg F, cooling to room temperature, three hours at 850 deg F. (3) Welded tubing, minimum tensile properties.

Table IV

Average Tensile Properties of AM-355 Castings*

Test Temperature (deg F)	Room	800	900
0.2% yield strength (psi)	175,000	135,000	125,000
Tensile strength (psi)	220,000	195,000	183,000
Elongation in two inches (per cent)	15	12	12
Area reduction (per cent)	35	28	25

* Homogenized, annealed at 1750 deg F, subzero-cooled at —100 deg F, and tempered at 850 deg F.

ventionally desirable hardness for machining, but it causes the least chip breakage and gives the longest tool life. Plate is available annealed or equalized and overtempered. Hardening is then done by either the SCT or the DA heat treatment.

Sheet and strip are also available in various cold-rolled conditions. Through a combination of the formation of martensite and of work-hardening, the alloys can be cold-rolled in two ways:

- to the cold-rolled and tempered (CRT) condition, with strength and ductility levels comparable to the SCT conditions;
- to the extrahard (XH) condition, with tensile strengths as high as 350,000 psi.

Both alloys are obtainable in the CRT conditions; the XH condition is confined at present to AM-355 in gages under 0.012 in. and widths of less than 24 in. The "subzero cooled, cold-rolled, and tempered" (SCCRT) cold-rolled condition is available in AM-355 at a tensile level of about 290,000 psi. Another recent development in cold-rolled worked material is cold-drawn and tempered AM-350 welded tubing.

The cold-rolled tempers are not full production items, though they are made (with mill equipment) in substantial quantities. The amount of reduction controls the resultant properties, with the power requirements limiting the gage maximum. The cold-rolled tempers are available in coil form only.

When the formability requirements aren't too stringent, the cold-worked materials provide strengths equal to or higher than the maximum obtainable by heat treatment. The CRT condition has enough ductility for moderate forming and has been used for corrugated cores of spot-welded sandwich structure. The XH and SCCRT conditions are being used for skins of spot-

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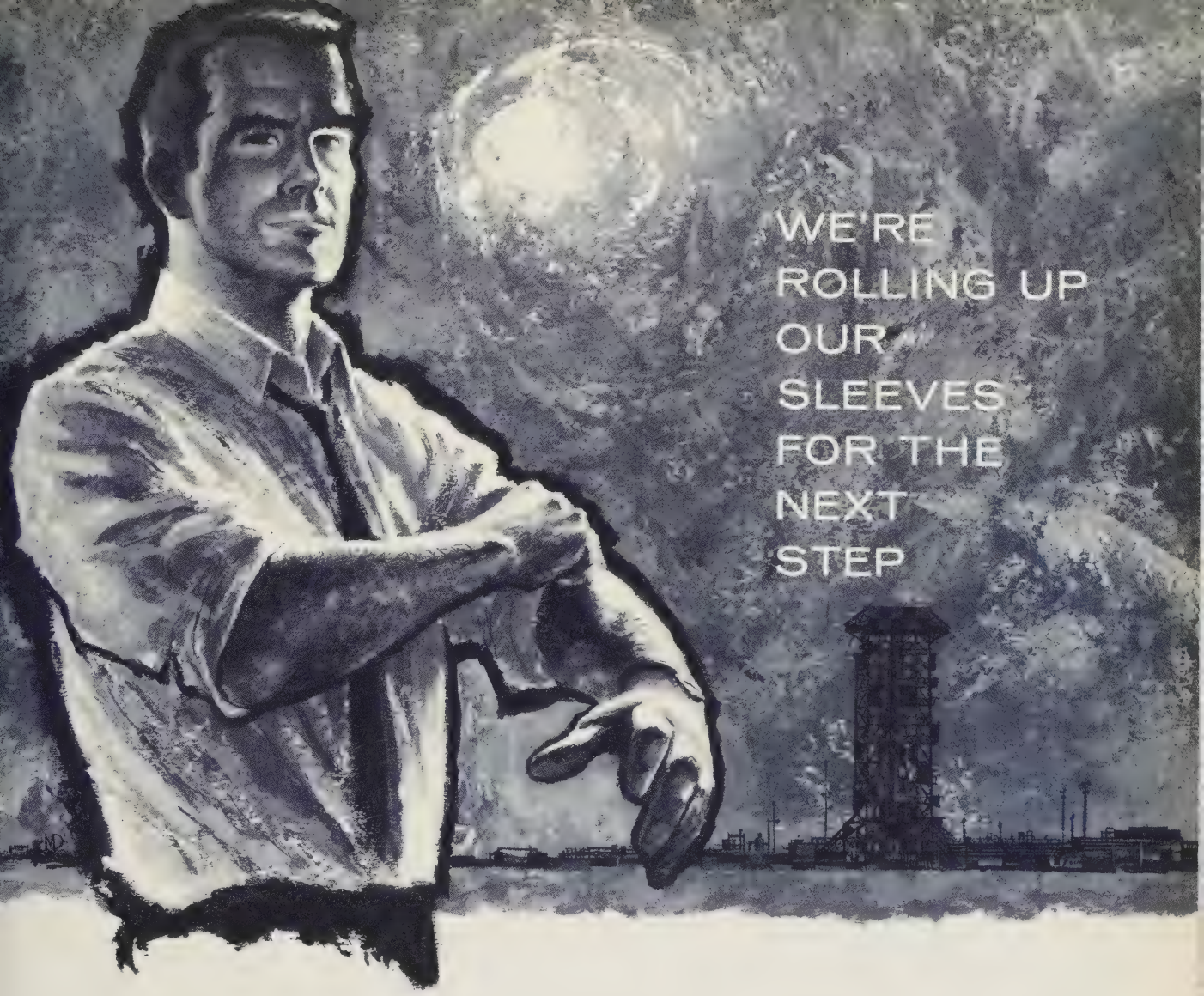

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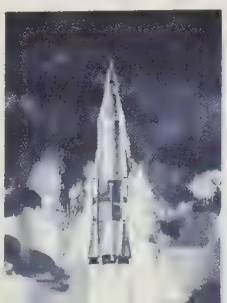

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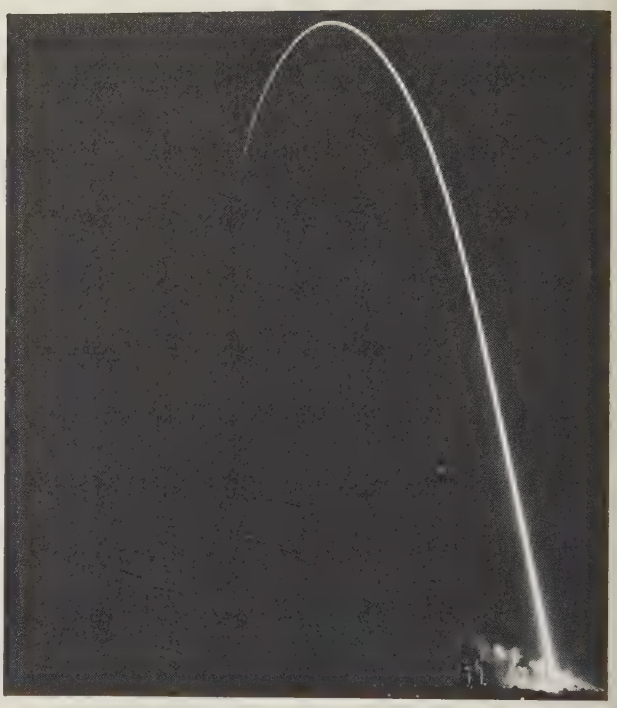

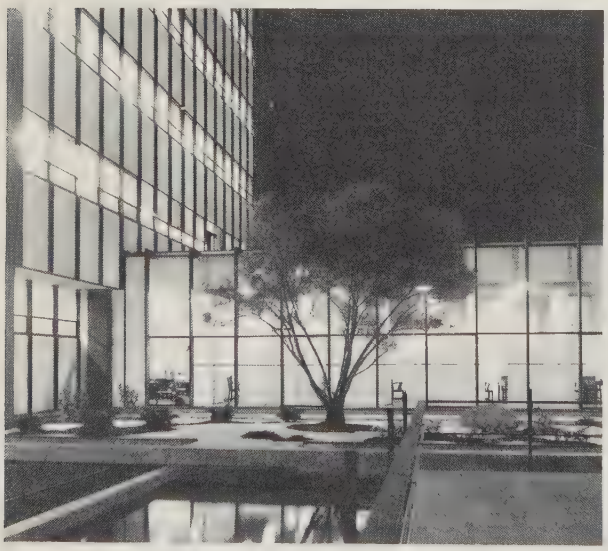

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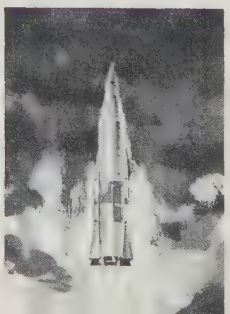

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Table V

Tensile Properties of AM-355[1]

Test Temperature (deg F) & Direction	0.2% Yield Strength (psi)	Tensile Strength (psi)	Elongation in 2 In. (per cent)	Modulus of Elasticity (10^{-6} psi)
		CRT[2]		
room, L	215,000	234,000	20	29
room, T	200,500	235,000	16	28.7
400, L	186,500	209,000	6	25.9
600, L	171,000	202,000	7	24.6
800, L	148,500	186,000	8	24.2
800, T	149,000	193,000	6.5	24.8
900, L	144,000	174,000	6	23.8
900, T	136,000	183,500	5	25
1000, L	116,500	139,000	5	24
1000, T	123,000	149,000	4	26.2
		SCCRT[3]		
room, L	287,000	288,000	1.0	29.9
room, T	280,000	293,000	2.5	31.1
200, L	290,000	290,000	1.0	28.5
200, T	272,000	282,500	2.0	31.1
400, L	274,500	282,000	1.0	26.9
400, T	258,000	281,000	1.5	27.6
600, L	254,500	268,500	3.0	26.1
600, T	240,000	272,500	3.5	27.0
800, L	236,000	249,000	2.5	25.3
800, T	224,000	255,000	4.0	25.3
900, L	213,000	225,000	2.5	24.5
900, T	202,000	223,500	2.0	23.6
1000, L	145,500	152,500	2.0	20.3
1000, T	143,500	166,500	4.0	23.5

(1) Specimens held 20 minutes at temperature before testing. (2) On 0.056 in. gage. (3) On 0.018 in. gage.

welded sandwich structures, ribbon-wrap for pressure vessels, etc. CRT AM-350 welded tubing is being used for aircraft ducting.

Table III shows typical tensile properties (for sheet) at room temperature. In the annealed condition, AM-355 has less elongation than AM-350, but somewhat higher strength (following SCT or DA hardening). The CRT condition combines high strength with excellent elongation; the SCCRT and XH conditions offer extremely high strengths. *Table VIII* gives elastic constants in the SCT condition.

The *Graph* and *Table I* respectively show impact and tensile properties SCT of AM-355 bar for final tempers of 850 and 1000 deg F. The strength of bar and forgings is generally similar to that of sheet. While a 1000-deg F temper results in lower tensile and 0.2 per cent yield strength, the 0.02 per cent yield is slightly higher, and area reduction and impact energy are much higher. Finish-machining is much easier with a final temper of 1000 deg F, the hardness being about 49 R_C.

Table VII shows stress rupture properties for AM-355 bar. The curves for stress vs rupture time are nearly horizontal up to a test temperature of 800 deg F, and the stress values are only slightly lower than the short time tensiles. After 1000 hours at or over 900 deg F, the stress-rupture strengths of material tempered at 850 or 1000 deg F are similar.

Tables II & V give tensile and stress-rupture properties for the CRT and SCCRT conditions. Beyond about 500 deg F, the tensile strength for CRT is slightly less than that for SCT. The 0.2 per cent yield in the CRT condition remains somewhat higher than that for SCT up to 1000 deg F. Both tensile and yield strengths in the SCCRT condition are higher than those for SCT and CRT. However, they decrease with increasing temperature

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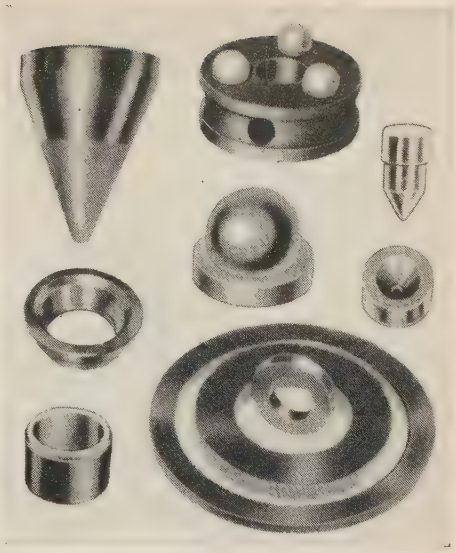

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Table VI

Nominal Alloy Compositions

	AM-350	AM-355	Modified (Casting)
Carbon	0.10	0.14	0.10
Manganese	0.75	0.75	
Silicon	0.30	0.30	0.60
Chromium	16.50	15.50	15.00
Nickel	4.25	4.25	4.20
Molybdenum	2.75	2.75	2.30
Nitrogen	0.09	0.10	0.09

Table VII

Stress-Rupture Properties of SCT AM-355 Bar*

Test Temp. (deg F)	Stress for Fracture (psi) In 10 Hr	In 100 Hr	In 1000 Hr
Tempered at 850 Deg F			
800	188,000	185,000	182,000
900	141,000	120,000	98,000
1000	88,000	72,000	58,000
Tempered at 1000 Deg F			
800	140,000	138,000	135,000
900	110,000	105,000	99,000

* 1750-deg F water quench, three hours at —100 deg F, and three hours at tempering temperature.

so that, at 1000 deg F, the tensiles in all three conditions are nearly similar.

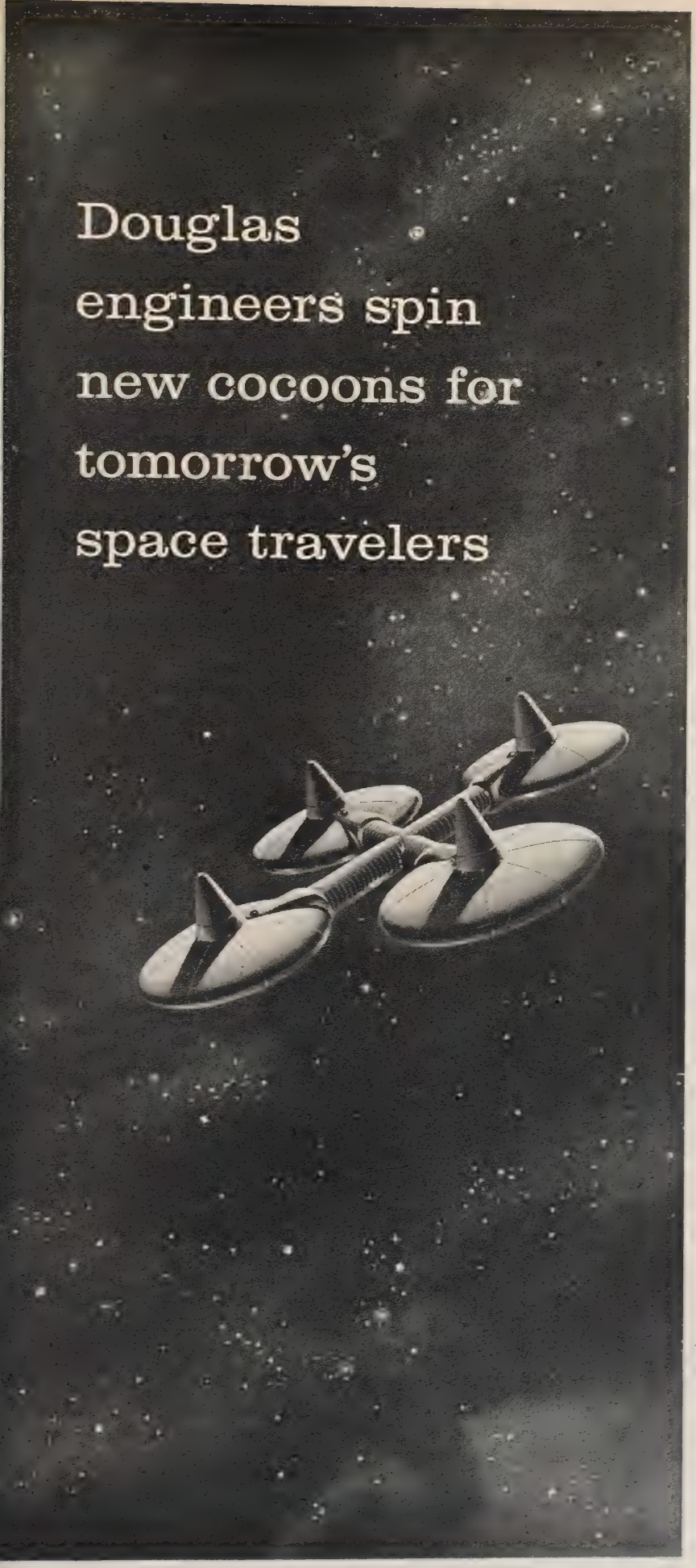
At 800 and 900 deg F, the rupture strengths for CRT is slightly higher than for SCT up to a rupture life of 1000 hours. While the rupture strength for SCCRT at 900 deg F is higher for a rupture life of 10 hours, the strength in 100 hours about equals and that in 1000 hours is below the values for the CRT and SCT conditions.

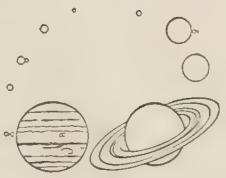
As we've noted, the composition for castings was modified to obtain optimum mechanical properties (*Tables IV & VI*). Homogenizing at 2000 deg F is desirable to eliminate microsegregation; it should be followed by annealing, cooling, and tempering. If machining is needed, it's recommended that castings, like bars, be equalized and overtempered after homogenizing. After machining, they are hardened by 1750-deg F anneal plus the SCT treatment.

The general corrosion resistance of AM-350 and AM-355 more closely approaches that of the austenitic stainless steels than that of the martensitic steels. Because of their molybdenum content, the alloys are superior to Type 301 in

more on page 94

Douglas engineers spin new cocoons for tomorrow's space travelers





Space researchers in human factors engineering utilize latest discoveries of medical science

Each time a space traveler leaves home (earth) he has to be completely wrapped in a special environment. He needs it to survive under alien conditions such as extreme heat and cold, high vacuum, cosmic radiation and tremendous G forces.

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Out of these research activities and those made by companion workers in this field has come new knowledge of great medical importance . . . even to those of us who are earthbound.

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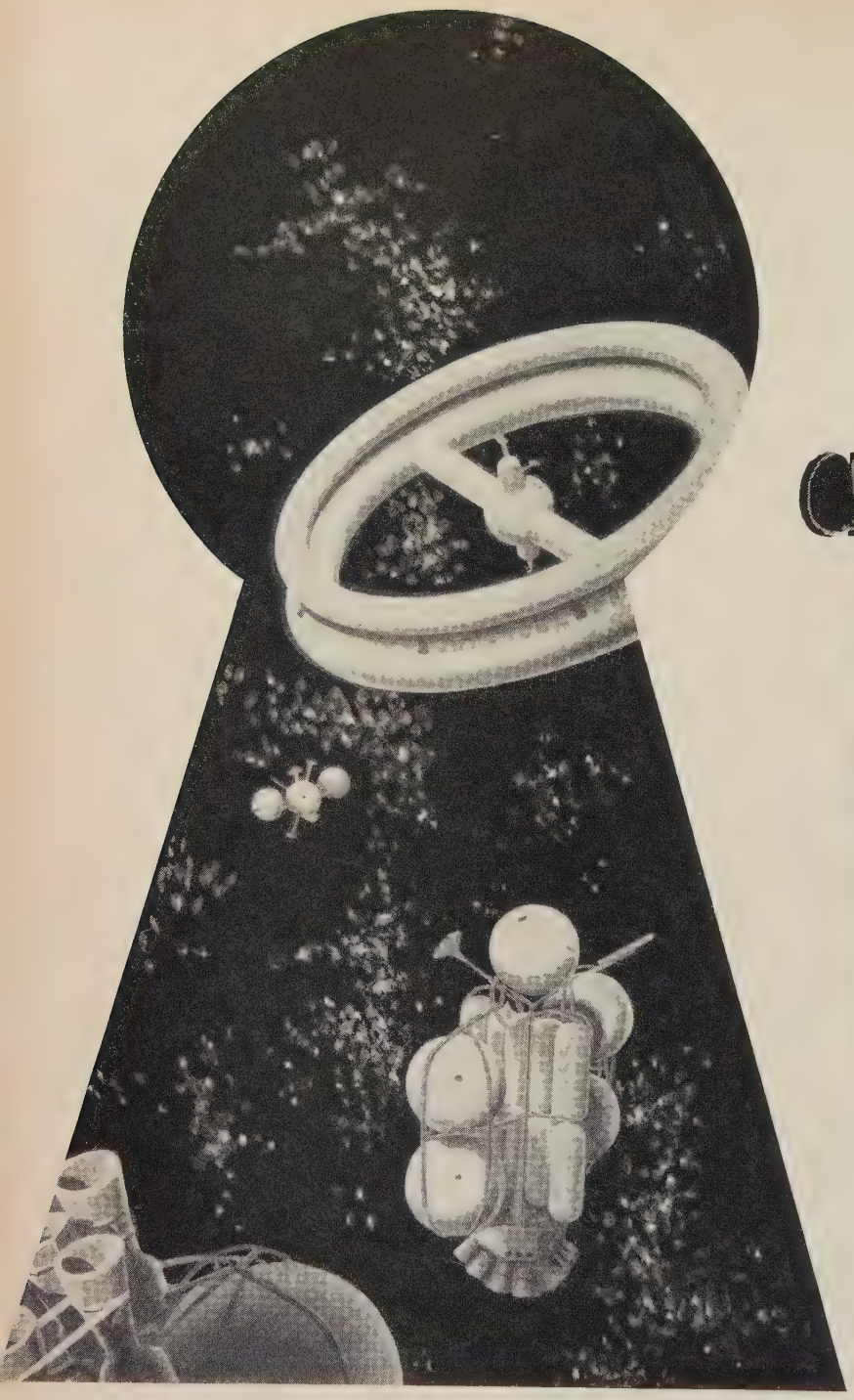
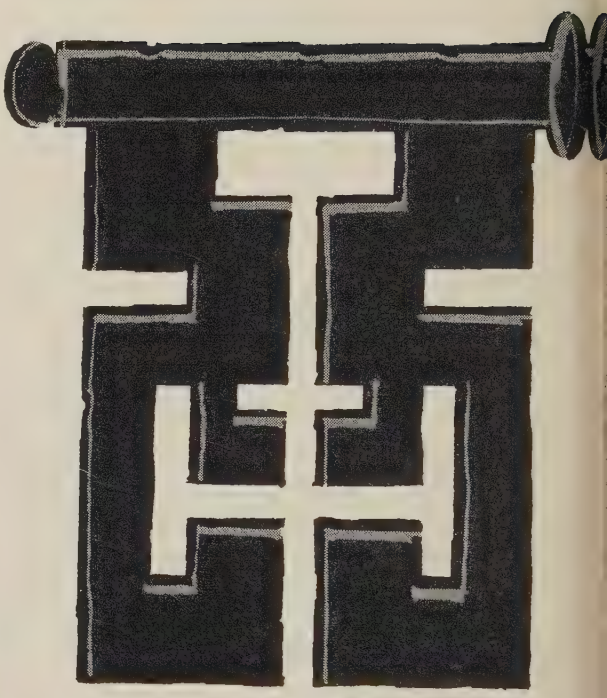
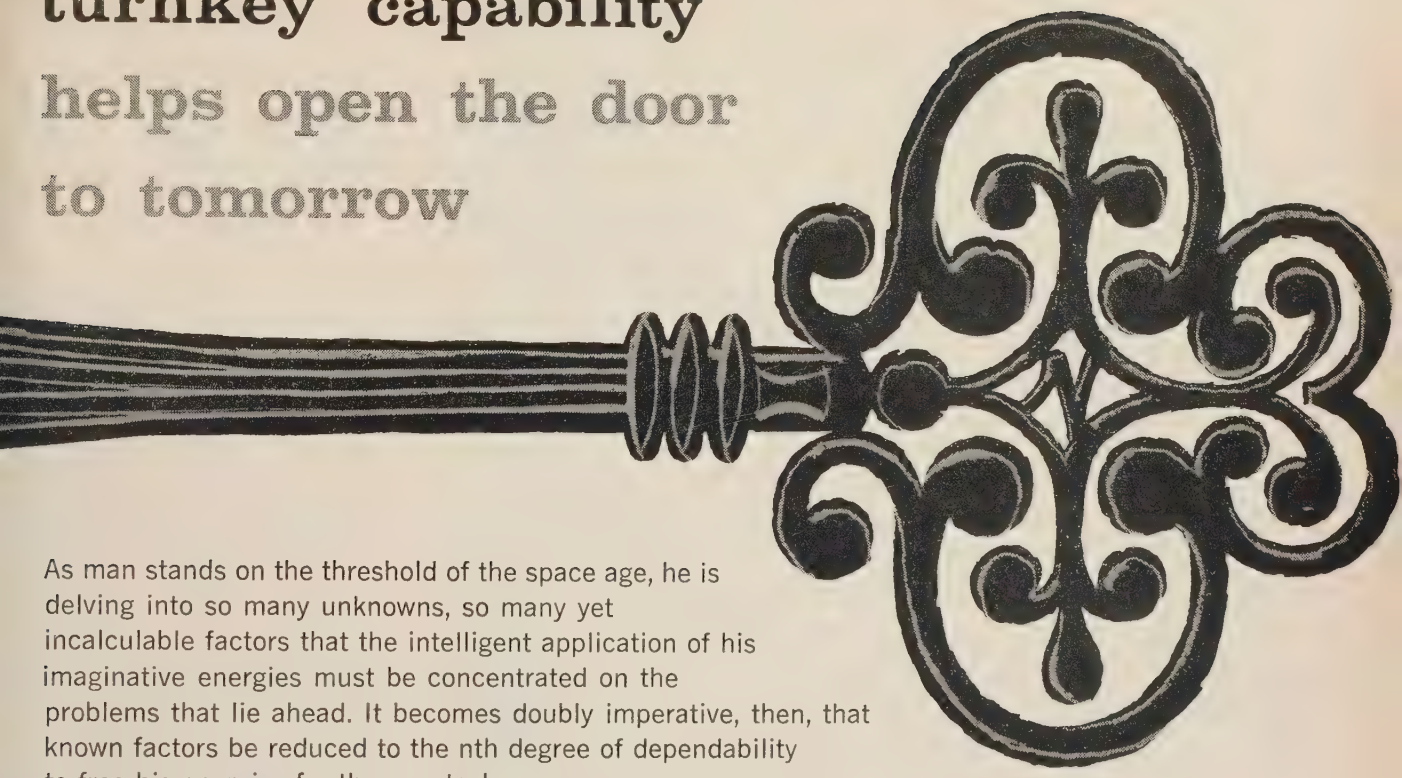




North Electric's "turnkey" capability helps open the door to tomorrow



As man stands on the threshold of the space age, he is delving into so many unknowns, so many yet incalculable factors that the intelligent application of his imaginative energies must be concentrated on the problems that lie ahead. It becomes doubly imperative, then, that known factors be reduced to the nth degree of dependability to free his energies for the new tasks that lie beyond the known.

North Electric has already been an invaluable partner in the first exploratory steps toward full realization of man's venture into space.

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Table VIII

Elastic Constants of SCT AM-350 and AM-355*

Test Temperature (deg F)	Young's Modulus (10^6 psi)	Modulus of Rigidity (10^6 psi)
	AM-350	
80	29.4	11.3
400	27.3	10.4
600	25.9	9.80
700	25.2	9.60
800	24.3	9.30
	AM-355	
80	29.3	11.4
400	27.3	10.5
600	26	9.93
700	25.3	9.63
800	24.6	9.35

*Ultrasonically determined on 7/8-in.-diameter bar at U. of Michigan after 1750-deg F Water quench, three hours at —100 deg F, and three hours at 850 deg F.

some media (e.g., a one per cent solution of sulphuric acid).

The resistance to rusting in salt spray and the stress-corrosion resistance to salt spray and solution generally are good. AM-350 is more resistant than AM-355 in the SCT condition; however AM-355 is more resistant in the CRT and SCCRT conditions.

A major advantage of the new alloys is that they're as weldable as the conventional Cr-Ni austenitic stainless steels. Neither the weld deposit nor the heat-affected zone hardens appreciably on cooling after welding. The alloys contain no copper, aluminum or titanium (which are generally incompatible with good weldability) and so have much better resistance to weld cracking than most high temperature alloys.

Circular-groove- and cruciform-weld-restraint tests show that the alloys have good hot-crack resistance. Preheating, post-heating, and interpass temperature control usually are not needed to prevent cracking. The alloys have been successfully welded by tungsten inert gas, short arc or dip transfer, consumable electrode inert gas, covered electrode, submerged arc, and inert gas spot weld. They can be welded in the annealed, equalized and overtempered, and fully hardened conditions. Circle No. 74 on Reader Service Card for more information.—End

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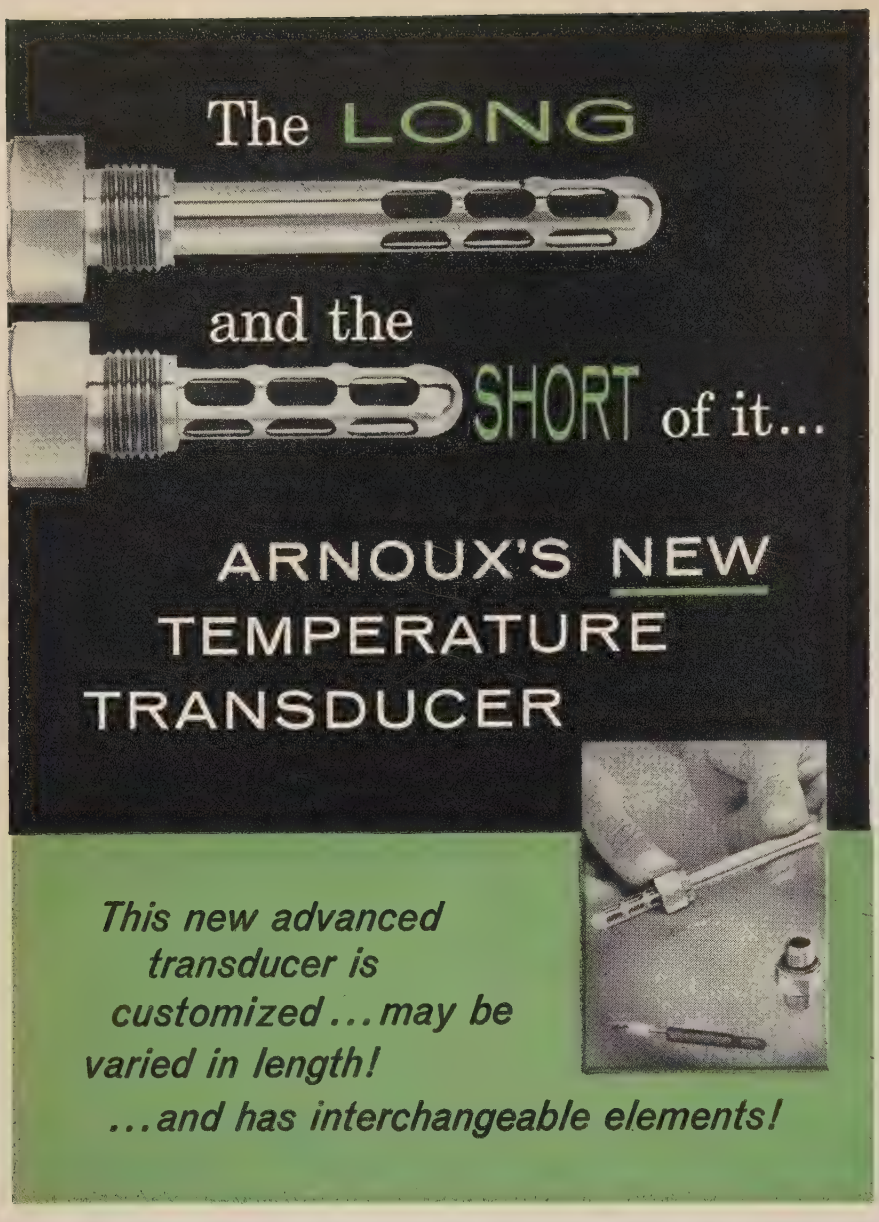

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books

Aircraft Electrical Engineering, edited by G. G. Wakefield. This book, one of a series on major aircraft design areas being prepared under the broad direction of the Royal Aeronautical Society, is intended as a general survey of the subject up to designs in the Mach 2 range. Special attention has been given to the presentation of environmental characteristics and the problems of high altitude brush wear. The MacMillan Co., 60 Fifth Ave., New York 11, N.Y. $10.

Hypersonic Aerodynamics, by R. W. Truitt. The fundamental principles of hypersonic aerodynamics and their application to missile design problems are covered in this text. Chapters include two and three dimensional hypersonic flow; minimum drag bodies; slender body theory: hypersonic small disturbance theory, etc. The Ronald Press Co., 15 E. 26th St., New York 10, N.Y. $10.

Advances in Astronautical Sciences, Volume IV. This volume gives the proceedings of the Fifth Annual Meeting of the American Astronautical Society, held in Washington, D.C., Dec. 8, '58. Subjects covered include upper atmosphere research and re-entry mechanics; space vehicle design; guidance and instrumentation; satellite mechanics and space exploration; rockets and satellites; and man's environment in space. Plenum Press, Inc., 227 W. 17th St., New York 11, N.Y. $8.

Space Age Dictionary, edited by Charles McLaughlin. This reference book is edited for the general reader and includes many illustrations, including 54 recognition silhouettes of U.S. rockets. D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N.J. $5.95.

Transistor Manual, Third Edition. Published by GE, this covers basic semiconductor theory (briefly), circuits, applications and specifications. General Electric Co. Semiconductor Products, 1224 W. Genesee St., Syracuse, N.Y. $1.

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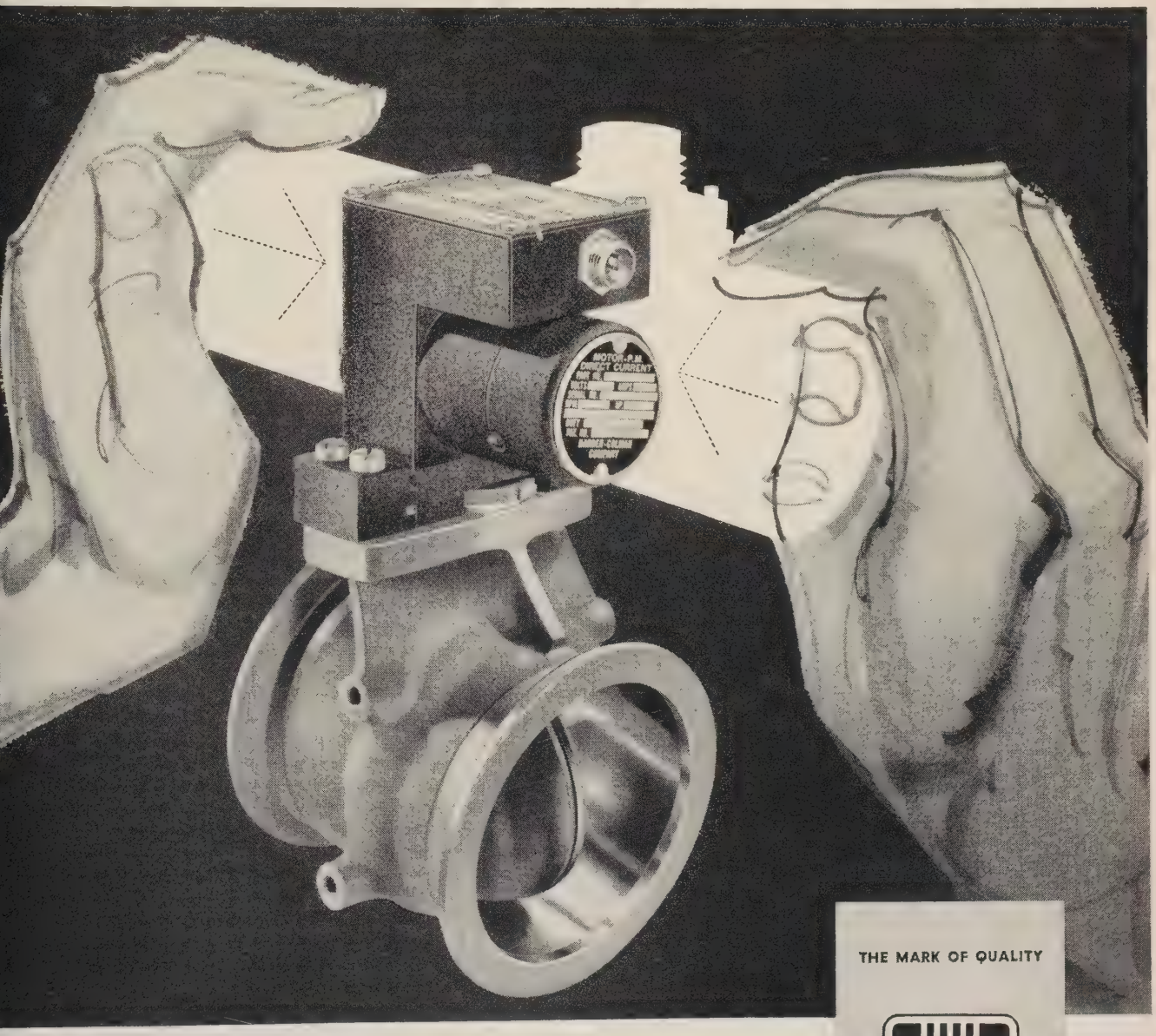

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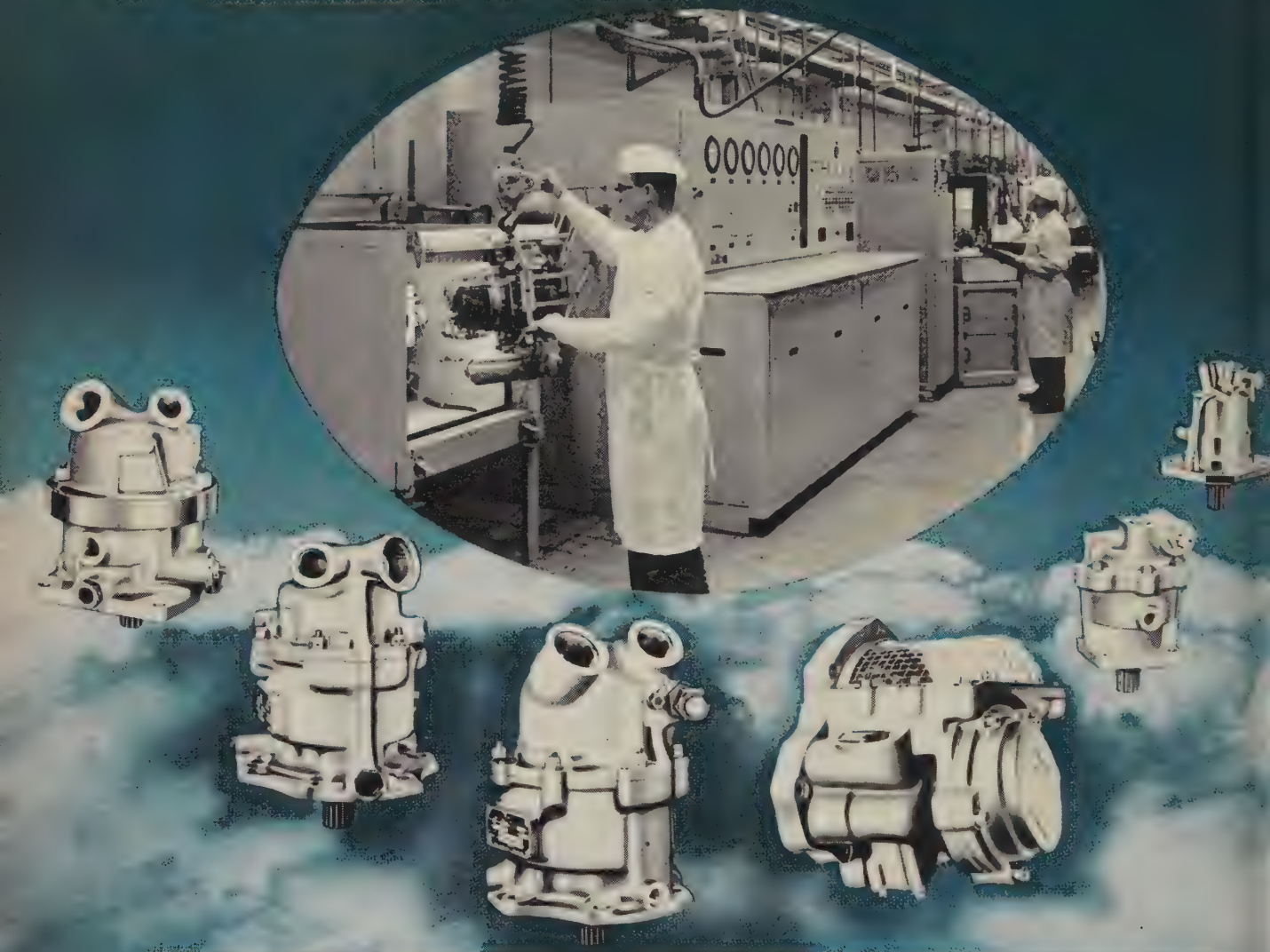

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P105	1.05	11.5	5500	24.0	.274	8000	35.4	.185	5.25	7.25
P65	.65	8.1	6000	16.2	.286	9000	24.6	.188	4.66	6.00
P56	.568	8.1	7000	16.5	.281	10000	23.9	.194	4.66	6.00
P16	.163	3.5	12000	8.0	.250	16000	10.8	.185	3.50	4.75
P11	.115	2.6	12000	5.7	.261	16000	7.7	.193	3.25	4.47
*Stainless Steel Housings with No Increase in Weight										
*P064	.064	2.1	12000	3.1	.388	18000	4.8	.250	2.125	3.35
*P044	.044	1.8	12000	2.15	.479	18000	3.3	.312	2.000	3.06
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Spark-bomb method promises

in-plant explosive forming

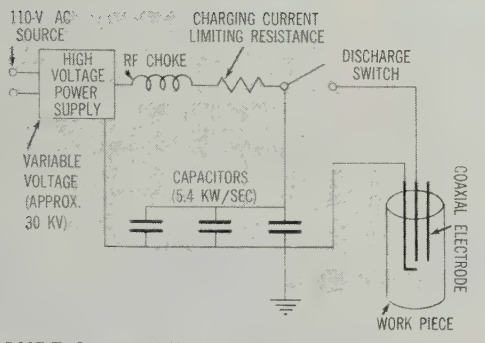


FIGURE 1: Republic spark bomb equipment was built almost entirely from commercial items. It's connected to 110-, 220-, or 440-V shop supply. Current feeds to a grounded high voltage supply or step-up transformer, thence to an RF choke, a charging current limiting resistance, the first steel ball in a discharge switch, and finally to a bank of 50,000-V capacitors assembled in parallel. At discharge, Plexiglas plate is withdrawn from between the steel balls. The spark jumps the gap and then across the electrodes in the die to ground.

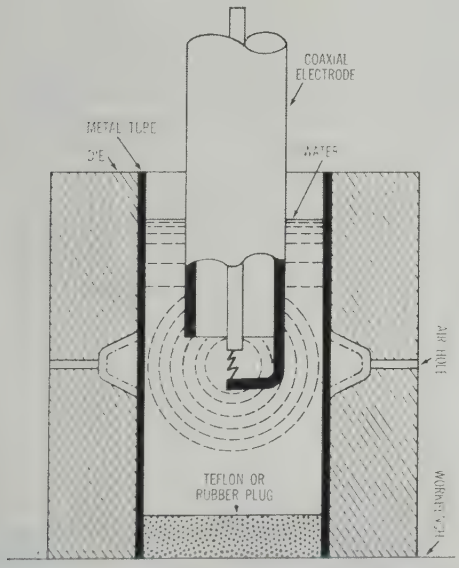


FIGURE 2: Republic researchers selected bulging as the best way to evaluate the spark bomb process, since it is convenient for measuring the amount of work done. In this setup, lines scribed at ⅛ in. intervals reveal stress-strain properties by their displacement.

High-energy rate forming is the prime hope for overcoming the production bottleneck caused by the new hard-to-form materials. One of the newest high energy approaches uses electric energy instead of explosives.

SPARK-GAP forming is the latest development in the rapidly expanding field of high-energy rate forming. Typical of the work being done in this new area is the "spark-bomb" process developed by Republic Aviation Corp., Farmingdale, N. Y.

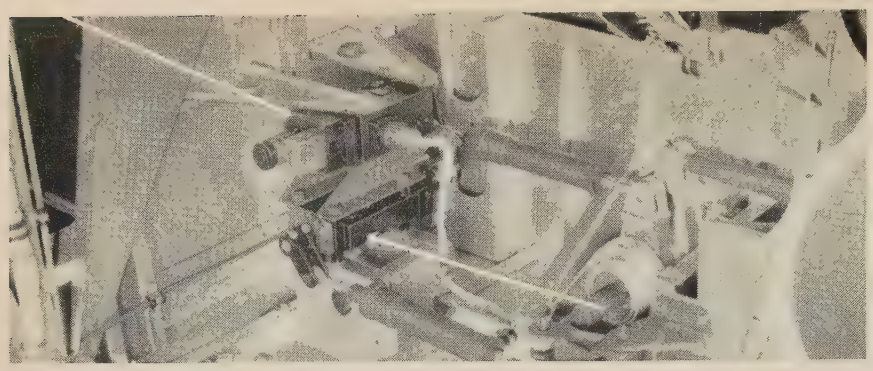
In this method—which is still in the research stage—electric energy is stored in high-voltage capacitors and then released in forty millionths of a second across a gap between electrodes submerged in water inside a die. The resulting explosion creates a shock wave, which does the forming. As in other explosive forming methods, high-tensile-strength materials and those that don't lend themselves to conventional press forming can be shaped in a die cavity without fracture.

As Republic engineers pointed out to SPACE/AERONAUTICS, one of the advantages of the spark-bomb process is that it can be used right in the plant on the production line. For other current methods of explosive forming, you need special pits or outside structures, since actual explosive powders are used. The Republic method also is more easily repeated—you dont' have to prepare new charges for each part.

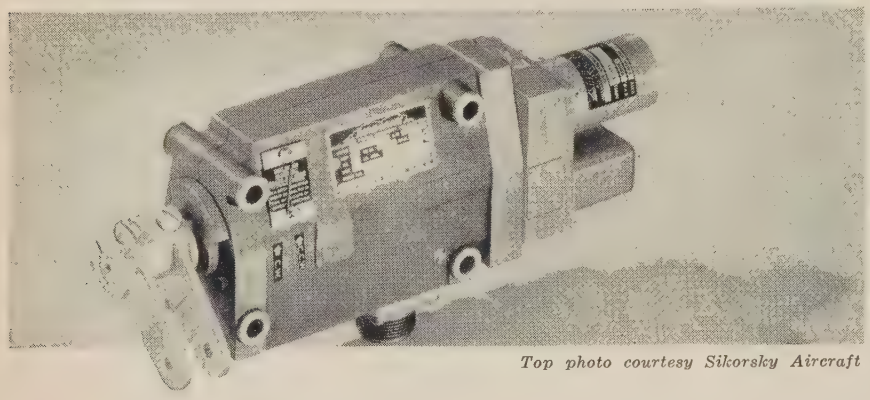
The process can be used to make relatively small parts; for instance, Republic has made 1½-in.-diameter parts without any trouble from a wide variety of materials. Company engineers believe they couldn't make such small parts by other explosive methods without getting pitting on the inside surfaces.

Although a tremendous amount of force is exerted during the work-time interval (1800 joules in the device of *Figure 1*), the electric power needs of the system are low. Charging time depends on the desired

more on next page



Trim system of Sikorsky HUS-1 and HSS-1N helicopters utilizes two special Airborne rotary actuators, acting through force gradient springs, to position and hold cyclic sticks. Pilot can override springs to maneuver; then have stick return automatically to trimmed position.



Top photo courtesy Sikorsky Aircraft

Airborne special actuators provide helicopter trim control

One of the more recent applications of Airborne special design actuators is found on Sikorsky's HUS-1 and HSS-1N helicopters. Two Airborne R4610 TRIM TROL units are used on these aircraft as moveable anchor points for a force gradient system of trim control. The system is an ingenious one, offering the pilot several control options.

For example, to make a quick maneuver, he can override the force gradient springs manually, without disengaging the actuator clutches. When released, the stick then returns automatically to original position. Alternatively, he can disengage the clutches by pushing the stick trim button, thus removing the force gradient system from the controls while maneuvering to a new flight condition. In this instance, the stick remains spring centered in the new position when the button is released.

A third control option permits changing flight attitude by power. Using a "beeper" button, the pilot energizes the actuators to drive the stick slowly to a new trim position, where it remains centered when the button is released. Finally, the system can be disconnected entirely, leaving the stick free and without artificial feel.

A detailed description of this system and the actuators employed is contained in new Airborne Bulletin PS-3A, available on request.

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FIGURE 3: Female die was used to obtain sharp bulge in this aluminum part. Tube has 0.035 in. wall thickness and is 1¼ in. in diameter and two inches long. Bead has a ⅛-in. radius.

operating voltage and the rating of the high voltage supply. Thirty seconds, it's stated, may be considered normal. The system may be discharged at any time after this interval upon the operator's command.

Only distilled water has been used so far

Different kinds of liquid media probably can be used; so far, Republic has run tests only with distilled water. In the present setup, four capacitors are used that can charge to 30,000 V. At this voltage, Republic engineers say, a spark will jump 1¼ in.

Since the spark-bomb method is still experimental, SPACE/AERONAUTICS was told, it's imposible to predict the probable maximum size of work it eventually will handle. Small tubes were processed first to prove the theory. Electrodes were centered precisely in the beading die to give the sharply defined bulge shown in *Figure 3*. Bulging was selected as the best way to determine stress-strain characteristics (*Fig. 2*). In other tests, tubes were also free-formed without a die.

Only a female die is needed. It can be of iron, steel, concrete, or Kirksite, tests show. Parts as large as 3-4½ in. in diameter have been successfully formed on present equipment. The materials that have

been formed include aluminum and various stainless steels.

Electrode arrangement details are being worked out for sheet forming and deep drawing. Republic researchers believe the method should be good for sheet forming, including very thin sheet. They state that, if you used a pneumatic approach with thin sheet, you would punch right through the material—something that shouldn't occur with the spark-bomb method, they say.

Available voltage and its use are important

Obviously, in a draw die the pair of electrodes or pattern of multiple electrodes must replace the punch and its action. Republic engineers state that they have enough data on how metal is moved by electric discharge forces to let them experiment with involved die designs. Important factors are the distances between the electrodes and the end contour.

Varying the gap has some effect as well, but by far the most important overall factors, tests show, are the available voltage and its use. Process control instrumentation, engineers say, will be simple. Through trial it will be possible to duplicate results to close tolerances by setting controls to a specified voltage, they believe. "Firing" can then be done manually or automatically.

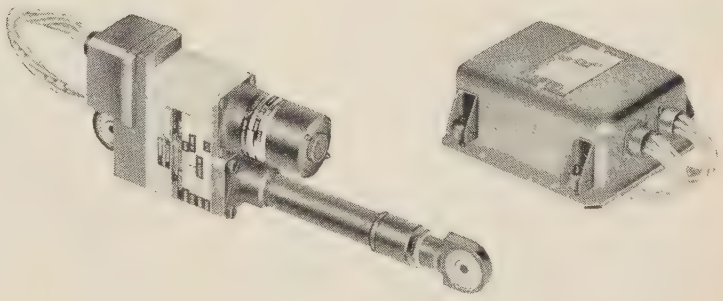
More than substitute for punch presses

The electric characteristics of the process, say Republic researchers, indicate that it won't merely be a substitute for ordinary punch press work. In the half minute it takes to charge the capacitors, they state, the part can be loaded with little idle time. In addition, if you had two banks of capacitors, each could be timed in relation to the other to fire every 15 seconds to handle fast-fed parts or supply successive shots of energy for completing a piece.

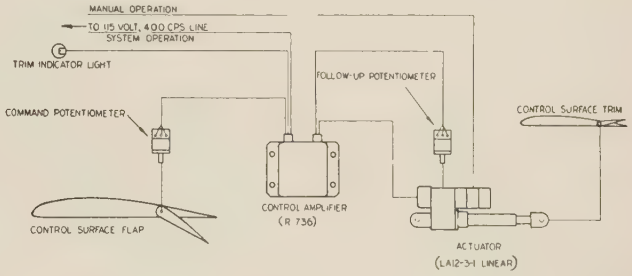
Republic intends next to build a production machine that will do the work of a small press. Eventually, larger machines may do the work of very large conventional presses at a fraction of the presses' cost and floor space requirement. Circle No. 73 on Reader Service Card for more information.—**IS**

AIRBORNE

electromechanical system provides automatic trim control for T-38



Schematic diagram shows Airborne automatic horizontal stabilizer trim control system on Northrop T-38 Talon. Control is achieved by d-c signals from 1000-ohm potentiometer on flap and followup from similar potentiometer on actuator. System functions only when flaps are lowered, with signal light indicating completion of adjustment for flap position selected.



Automatic horizontal trim control on Northrop's T-38 Talon high-performance jet trainer is provided by an Airborne electromechanical system comprised of an electronic control amplifier and an Airborne modular-type linear actuator. The system functions when the flaps are in use. At other times, the actuator is manually controlled by the pilot.

Sealed relays especially selected for their reliability characteristics are used in the output stage of the amplifier to control the 115-v, 400-cycle supply required by the brake-equipped actuator. The step function thus provided assures positive release of the actuator brake.

Control is simply achieved by d-c command signals generated by a 1000-ohm potentiometer on the wing flap and followup from a similar potentiometer on the actuator. Hysteresis of the control circuitry is deliberately broad to preclude hunting.

The entire system is designed for extreme compactness and light weight. The actuator is the smallest of Airborne's modular-design series, weighing only 1.4 lb., yet providing 75 lb. output. The control box measures only 1.6 x 4.2 x 3 in. and weighs just 1.2 lb.

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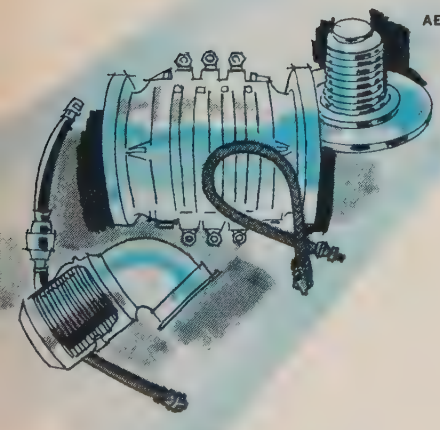

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Building your own combined environment tester

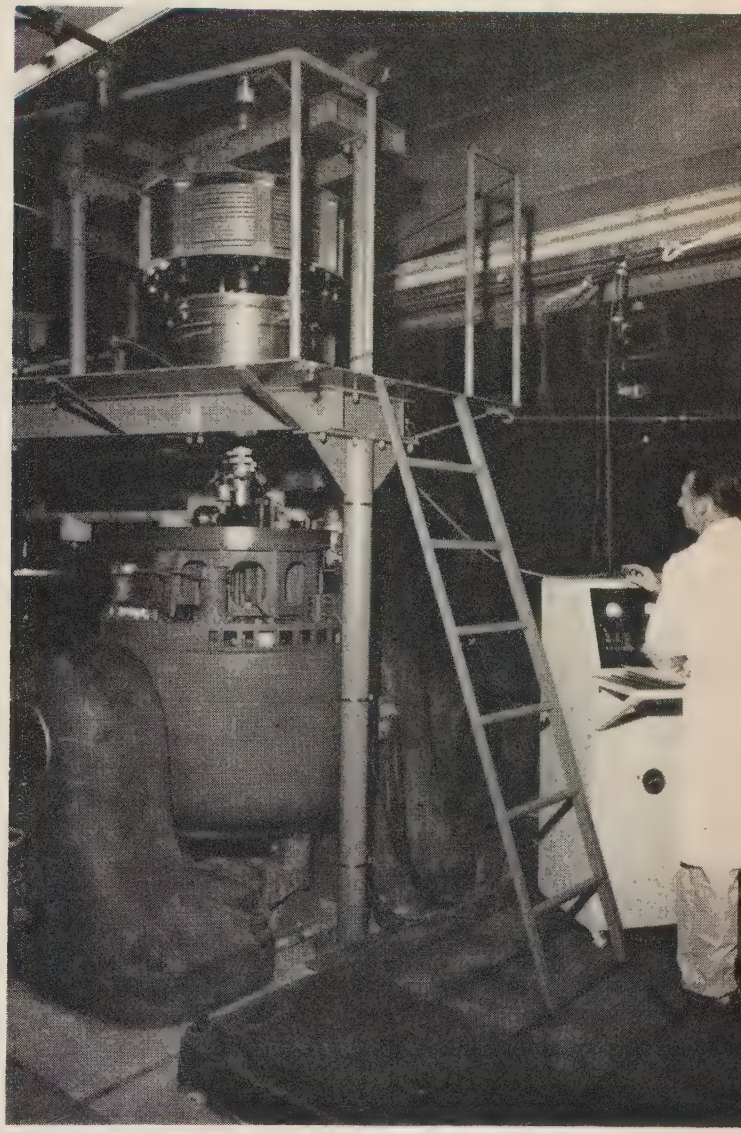

FIGURE 1: "Home-made" test fixture for combined environment tests weighs 2000 lbs.

It's true that testing has become much more complicated as we advance into new environments. But does that necessarily mean that testing must also become much more expensive? It doesn't—not if AiResearch's experience is any criterion.

by O. B. Farley and J. B. Fellows,

Laboratory Engineering, AiResearch Manufacturing Co. of Arizona*

TO SIMULATE the entire environment to which a missile component is exposed during engine firing and the first few seconds of flight AiResearch designed a 200-lb test fixture that can be built from commercially available items. Specifically, the fixture was to be used to test a small valve flowing helium at cryogenic temperatures while subject to flight acceleration, vibration, altitude effects, cold or hot ambient temperatures, and high humidity.

The toughest combination of environmental requirements seemed to be that of 35 g flight acceleration and vibration of the test unit at 10-2000 cps. We studied several methods of combining these two conditions:

- placing a vibration exciter on a large centrifuge and whirling the shaker in a circular path,
- spinning the exciter about an axis through the centerline of the machine and applying vibration through a mechanical linkage to the test unit,
- building a small centrifuge on top of a vibration exciter.

more on next page

* AiResearch Manufacturing Co. of Arizona, 402 S. 36th St., Phoenix, Ariz. The authors wish to acknowledge the advice and help of J. Livingston, Dr. B. Fried, A. Finkelstein, C. J. McKenzie, E. B. Butler, J. Peterson, and Dr. J. Lambert in the design, fabrication, and testing of the unit described in this article.

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The first method was dropped when we found that, with vibration in the plane perpendicular to that of flight acceleration, the rotation causes large side forces on the moving coil of the exciter. There was no time to develop an exciter of whose performance under this condition we could be sure. With a commercially available exciter, on the other hand, the risk of failure under the centrifugal load appeared to be too great.

The second method then was considered, since it would have reduced the centrifugal forces on the exciter. A quick analysis of the linkages through which vibration was to be applied showed, however, that the output from these would be too small (because of resonances and elastic deformation in the linkages).

The third approach, involving a centrifuge on top of an exciter, was successful (*Fig. 1*). The diameter of the head of the commercially available exciter that we chose is large enough so that a centrifuge of matching diameter can produce the required centrifugal force of 35 g at an acceptable turning speed.

The valve to be tested is mounted on a cart on the end of the arm of the centrifuge and travels in an annular track on top of the head of the exciter. While the valve is subjected to centrifugal force in the horizontal plane, vibration is applied in the vertical plane through the track onto the revolving cart and the valve.

The cart carrying the test unit revolves between an upper and a lower track. The force applied by the exciter is sinusoidal in form, vertically changing direction once in each cycle up to 2000 cps.

There is a set of ball bearings beneath the center of the cart that transmits the exciter force upward into the cart from the lower track surface. A set of outrigger bearings on each end of the cart transmits the exciter force downward into the cart from the upper track surfaces.

When the cart is placed in the track, the track is forced to deflect thereby loading the bearings radially. The amount of the load is greater than the applied vibratory forces. Therefore, during vibration the bearings always remain in contact with the track surfaces despite the quick alternation of loads applied by the exciter. As the de

more on page 10

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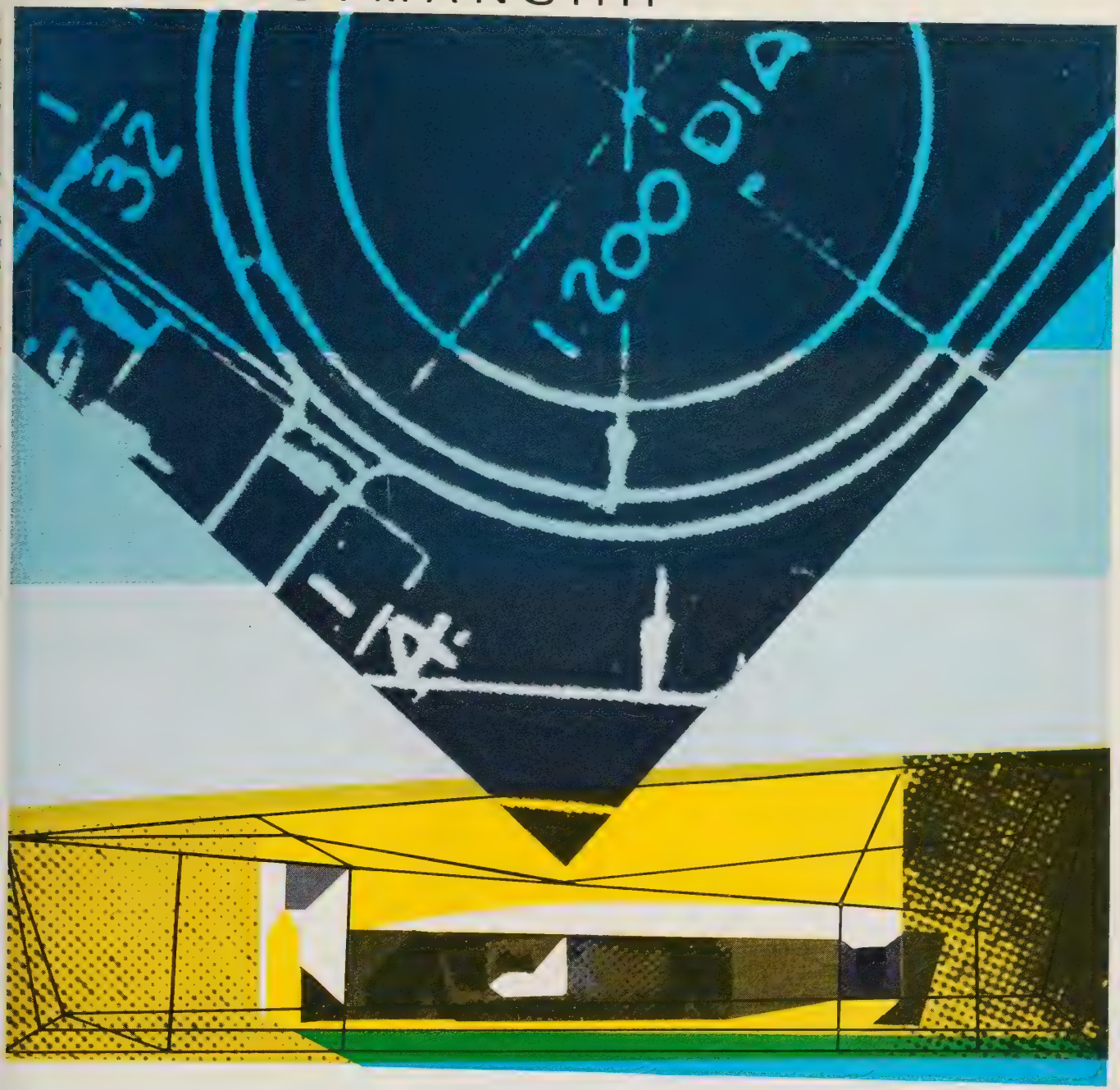

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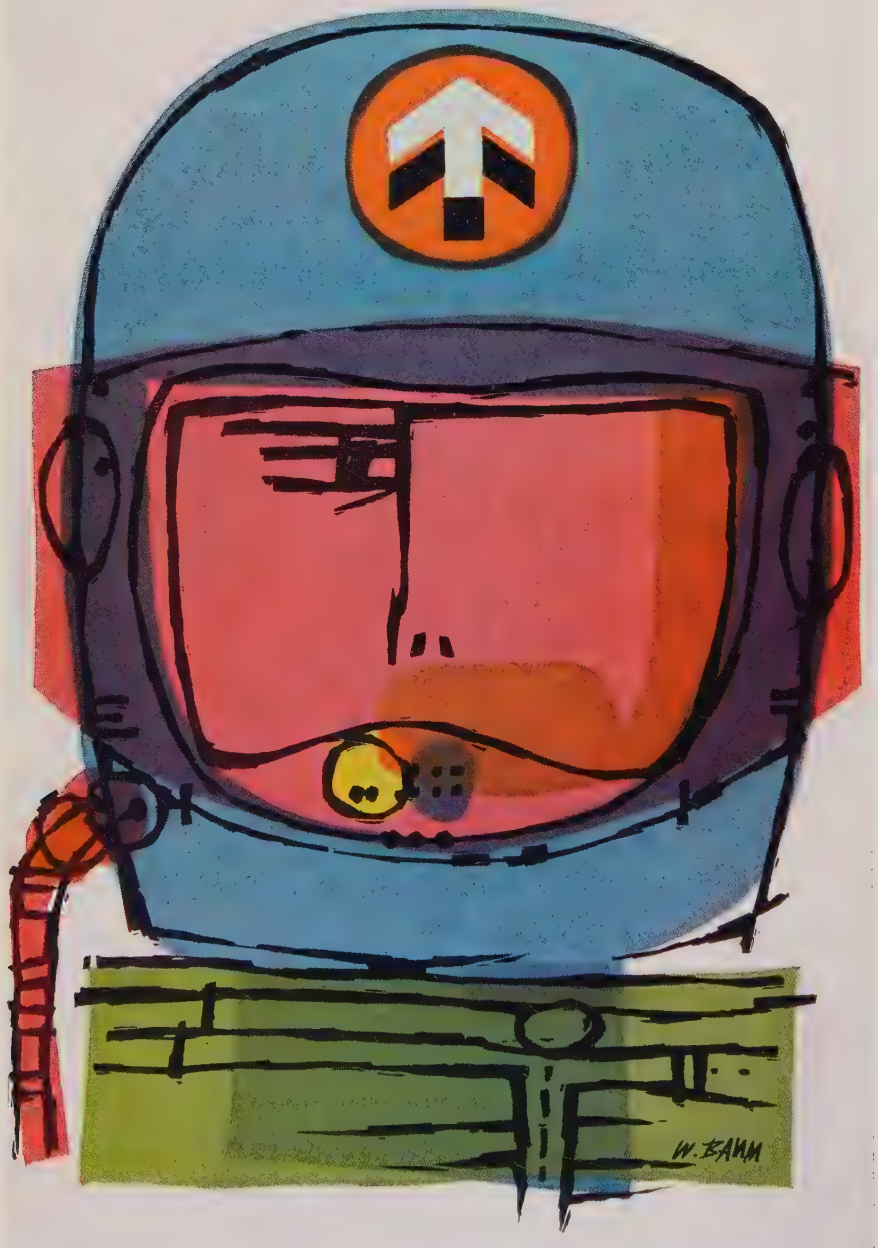

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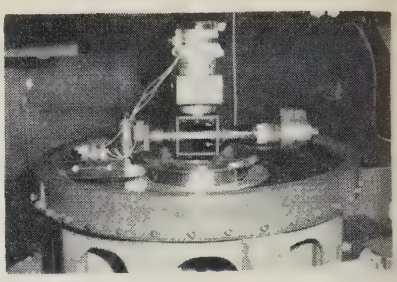

FIGURE 2: Final cart, shown with part of the test instrumentation, has two bearing-carrying sections. The lower fits into the upper, which is shaped somewhat like an inverted box.

flection of the track equals the deflection of the cart, complete bearing contact is maintained.

The first cart we designed moved back and forth on a short section of track. Analysis of test results showed that the bearings should be doubled in number to raise the natural frequency, so we redesigned the cart.

The final cart is made in two sections (*Fig. 2*). The upper bearings are housed in a section shaped roughly like an inverted box. The other section houses the lower bearings and fits inside this box. The two sections touch on an inclined plane surface running fore and aft inside the box.

The bearings are loaded radially by moving the two sections relative to each other along the inclined plane, with the cart installed on the track. The movement along the inclined plane increases the vertical distance between the bearing centerlines and forces the bearings against the tracks.

The upper track deflects as the bearings are loaded radially. The amount of load is set by turning two jack screws to a predetermined torque to move one section relative to the other. After loading, the two sections are locked together.

The cart and the arm of the centrifuge are connected by two ball bushings. These let cart and track move vertically through the amplitude needed to produce the vibration acceleration, yet isolate the centrifuge's weight from the exciter—the exciter moves the track, the cart, the test unit, and an insulated pressure vessel that surrounds the test unit.

It took several tries to work out a track and a cart that were neither too heavy for the force output of

more on page 108

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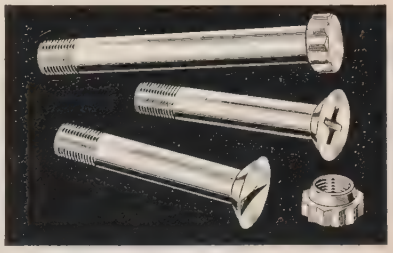

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12-Point (External Drive)	EWSB 26	EWSB 22

*Shown are room-temperature part numbers. See Bulletin 2477 . . . for 900° fasteners, Bulletin 2478.

®Hi-Torque Pat. Nos. 2,677,985; 2,745,120 (other U.S. and Foreign Patents)

®Torq-Set Pat. Nos. 494,726; 558,663 (other U.S. and Foreign Patents)

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available exciters nor resonant at the lower frequencies. A hollow rotating shaft drives the cart and its counterbalance. It extends vertically to an electric drive near the top of the test fixture, serving also as a conduit for instrumentation leads. These are connected to a 30-channel slip ring on the shaft. The shaft itself is connected through a swivel seal to the vacuum system at the upper extremity of the shaft.

At the shaft's bottom end, flexible tubing connects to the pressure vessel surrounding the test unit on the cart, which can simulate altitude conditions to 90,000 ft.

The vessel is internally insulated and cooled to extreme temperatures by helium at –300 deg F; it also can be heated electrically to +160 deg F. Steam is used to increase the relative humidity within it.

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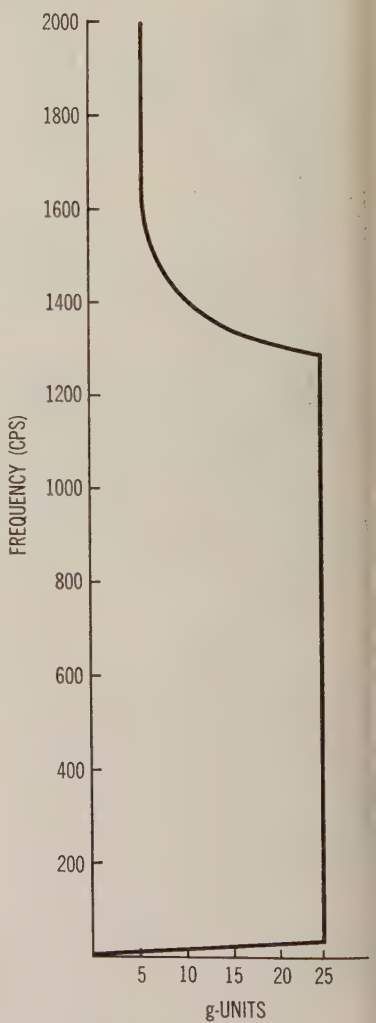
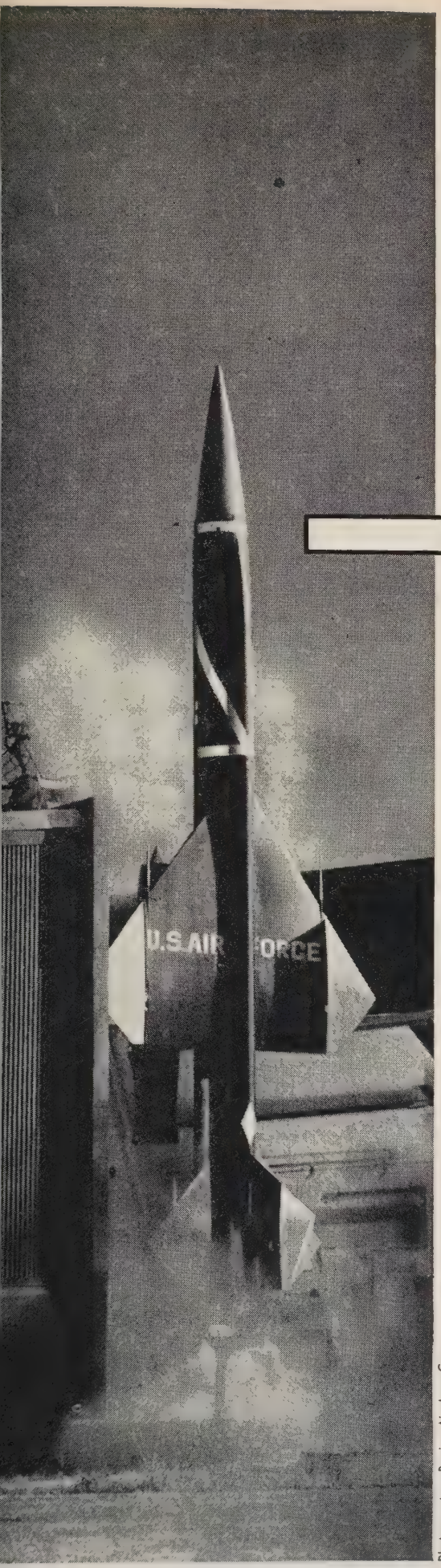
FIGURE 3: Vibratory acceleration performance of AiResearch's test fixture.





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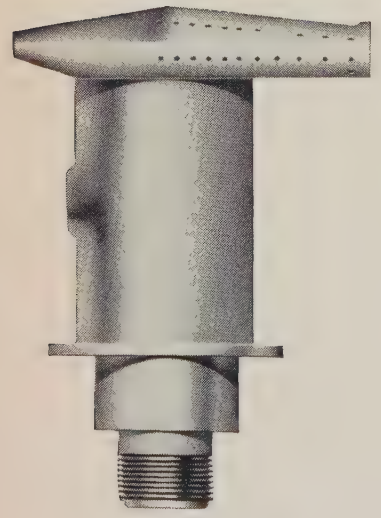

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Since most airborne missile parts are intended for a short life, only quite a short testing time gives, realistic results. Therefore, the amount of helium passing through the test unit is relatively small. In a pressure vessel turning with the centrifuge enough helium can be stored for one testing sequence. The helium is stored at 8000 psi in a vessel made of many coils of high pressure tubing wrapped around the driving shaft of the centrifuge. It is pumped up between tests and then blown down to 5000 psi during the test run.

The high pressure helium from the storage vessel flows through a pressure-regulating valve into a heat exchanger, which contains either liquid nitrogen for cooling or steam for heating the helium. The helium is transmitted to the test unit in the pressure vessel through tubing that is coiled through several loops and thus have no adverse effects on the vibration at the test unit.

As the helium is carried on board the centrifuge, there is no need for high pressure swivel joints. There is only one swivel joint in the entire fixture—it leads to the vacuum system, where leakage is neither critical nor hard to control.

The choice of the bearings to support and guide the vertical shaft was complicated by a number of variables. The centrifuge is supported from the top by ball bearings and guided from the bottom by a journal bearing. The latter, in addition to performing its usual functions also serves as a carrier for instrumentation leads and the tubing which, as we've seen, at times contains helium at 500 psi and –300 deg F.

The helium line must be insulated to prevent warming up of the gas and excessive chilling of the bearing. Conventional low temperature insulation is bulky and would result in a large-diameter bearing with high surface speeds. We therefore decided to use a vacuum-jacketed helium line through the journal bearing. The bearing then could be reduced to an acceptable size.

Performance tests on the combined vibration and acceleration fixture were run with the cart carrying a 7½-lb load (to simulate a five-pound test unit) and the pressure vessel. Vibration was applied from 10 to 2000 cps and rotational

more on page 114

TRUE NORTH... anywhere–any time–any weather

A portable field instrument that finds true north automatically is now available to America's new mobile Army. It is called ABLE and has been TYPE CLASSIFIED by the U. S. Army, TO & E No. LIN279415. ABLE swiftly determines true north . . . day or night, in all weather, and anywhere in the world up to latitudes of 70 degrees.

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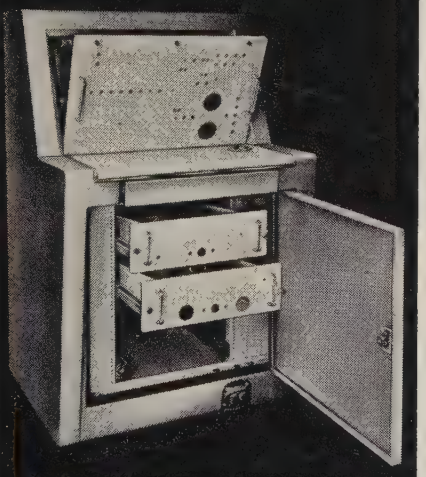
speed varied to produce centrifugal accelerations of up to 35 G. Rotational speed had no effect on vibration performance. Resonance in the fixture occurred at 800 cps.

The fixture produces a minimum of 25 G vertical vibratory acceleration from 34 to 1283 cps, while rotating to produce up to 35 g flight acceleration horizontally. From 1283 to 200 cps, the maximum vibration accelerations drops to six g. Below 34 cps, performance is limited by the maximum amplitude of motion of the vibration excited head (*Fig. 3*).

So far the fixture has run 15 hours with very little apparent wear on the bearings or the tracks. To prolong the life of the bearings, vibration is never applied unless the cart is in motion.—End

WHAT IS A STANDARDIZED CONSOLE



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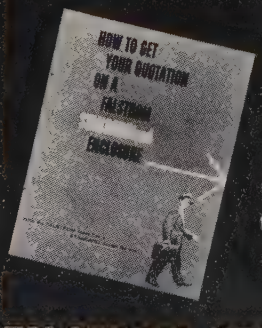

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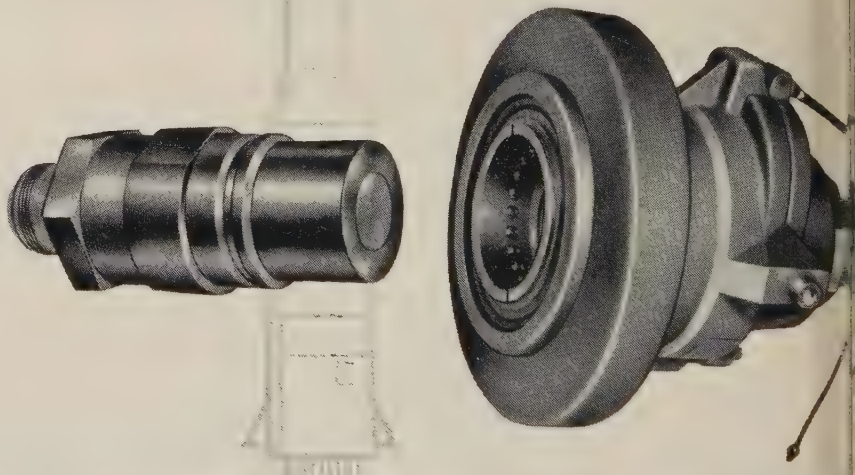

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- Pneumatic or lanyard-pull disconnect methods
- Choice of line sizes

Airaterra engineering and design makes possible the adaptation of these and oth couplings to meet your special requirements.

SOME OF THE OTHER POPULAR ROYLYN COMPONENTS
- Pneumatic Rise-Off Disconnect
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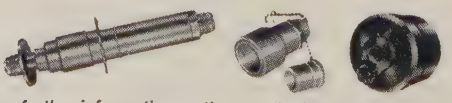

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New Concept
In Power Conversion For Jet Aircraft
MAIN ENGINE STARTING AND CONSTANT SPEED
ELECTRICAL POWER IN A SINGLE PACKAGE

THE **AIRESEARCH**
CONSTANT SPEED
DRIVE STARTER

is a combined generator, constant speed generator drive and pneumatic starter which will provide turbine-powered aircraft with main engine starting and full electrical power both on the ground and in flight.

Advantages are:

1. Combines in one lightweight unit pneumatic starting and electrical power. Utilizes starter turbine (which is normally considered as in-flight "dead weight") for constant speed trim.

2. Provides full electrical power on ground without operating main engines by using a source of compressed air.

3. Provides full electrical power in flight with a minimum use of bleed air for speed correction. Full electrical power can be maintained on a nonoperating engine by cross-bleeding air from operating engine.

4. The unit can be made self-contained on the ground or in the air by installing an AiResearch gas turbine into the aircraft. This closed system within the aircraft fulfills the three conditions listed above.

Other features: Extremely light weight... low oil heat rejection... self-contained, self-cooling lubricating system... high temperature operation... constant speed output pad available for additional accessories... up to 120 KVA.

A high degree of dependability has been achieved by using a turbine, gear train and control system similar to that employed in production air turbine starters and air turbine motors built by AiResearch which have accumulated thousands of hours of successful operation.

Your inquiries are invited.

THE GARRETT CORPORATION
AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

Systems, Packages and Components for: AIRCRAFT, MISSILE, ELECTRONIC, NUCLEAR AND INDUSTRIAL APPLICATIONS

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Titanium trims DC-8 airframe

(equals 5 passengers, or 1/2-ton of freight...*for life*

DOUGLAS AIRCRAFT COMPANY, INC., *has never built an airplane that failed to show a profit for its operators. Based on the experience of United Air Lines, the first carrier to fly the airplane, the latest Douglas ship, the DC-8 jetliner, indicates it will push this record forward. Here's how use of titanium contributes to the total efficiency of the airplane and what that efficiency means in dollars and cents.*

The flyaway airframe of the DC-8 jetliner provides its operators a basic economy almost anomalous in current design: payback on every flight without research or development costs to be amortized. That's how Douglas engineers state the value of titanium in achieving a minimum weight airframe structure.

Primarily an aluminum ship, the DC-8 offered few possibilities for weight savings during design. But where weight could be reduced – in pods and pylons, rip stoppers and door doublers–titanium was selected: –600 pounds of commercially-pure grade Ti-75A for pods and pylons; 330 pounds of Ti-6Al-4V titanium alloy grade for rip stoppers and door doublers; 15 pounds of miscellaneous titanium forgings. Metal is supplied by Titanium Metals Corporation of America.

The net result is elimination of a half-ton of needless airframe weight for the 5,000 flights each DC-8 is expected to make during its seven-year write-off.

TITANIUM ACCESS DOOR, through which DC-8 engine will be serviced, is installed on the aircraft by two Douglas Aircraft Company, Inc. employees. Pods of the DC-8 have been so designed that titanium will completely seal off any engine fire

TITANIUM RIP-STOPPERS play essential role in Douglas fail-safe approach to airplane construction. DC-8 uses 330 pounds of Ti-6Al-4V alloy titanium produced by Titanium Metals Corporation of America

y 945 pounds

TITANIUM ACCESS PANEL which covers engine in DC-8, complete with titanium details, measures 102" by 76" and weighs 80 pounds. Cumulative tolerances are controlled so closely at Ryan that each door is interchangeable with any pod built for a specific airline. 600 pounds of titanium (TMCA grade Ti-75A) are used in DC-8's pods and pylons

rpretations of the value of weight savings include:

DOUGLAS AIRCRAFT: "The 1,000 pounds (of weight saved) are equivalent to five passengers and their luggage for the entire life of the airplane."

UNITED AIR LINES: "At the very least, the weight saved by titanium is equivalent to a half-ton of cargo. At mail rates, this would amount to a potential of $525 for each coast-to-coast flight."

y titanium?

anium, with a density of 0.163 lb/cu. in. is produced in ngths equal to or surpassing steel on a strength-weight basis. resistance to atmospheric corrosion is permanent.

The reliability of titanium has been established with demonated clarity. Examples:

DOUGLAS has employed titanium in every commercial transport since its first DC-7, where titanium in firewalls, nacelles and landing gear doors yielded 200 pounds of weight savings.

PRATT AND WHITNEY AIRCRAFT reports that more than one million flight hours have been accumulated by more than 5,800 P & WA JT-3 and JT-4 engines using titanium components without a single failure of any titanium part, either through corrosion or mechanical damage. Both engines have been specified for the DC-8.

Alluding to titanium's reliability as its "sleeper property," W. Stuart Lyman, Principal Metallurgist, BATTELLE MEMORIAL INSTITUTE, made this comment in a lecture in Los Angeles March 19:

"We have talked with metallurgists from three large users of titanium recently. To a man, they reported that once titanium passes receiving inspection, gets fabricated, passes final inspection, and gets assembled into the airplane, it is usually never heard from again."

itanium competitive in price?

AN AERONAUTICAL COMPANY, which fabricates the bulk of the nium assemblies employed in the DC-8, commands industryle respect for its skill of craftsmanship and the attention to ail it brings to every job. Example: To guarantee maximum nliness, Ryan's DC-8 final assembly building in San Diego been so constructed that no doors or windows open in the ction of prevailing winds.

While overlooking no opportunity to impress upon emyees' minds that titanium metal costs more than steel, Ryan developed manufacturing techniques to fabricate titanium rices roughly equivalent to steel's. The spread between "input al" and completed assemblies is thus drastically narrowed e fabrication costs are, of necessity, far greater than raw erial costs.

Highlighting titanium's fabricability is Ryan's production he access panels which cover the DC-8 engines. These panels erally the doors through which engines will be serviced for — are made from three sections of 0.016" Ti-75A, 36" x 72", stretch-formed and welded together to form the skin of the npleted door. Details, such as stringers, channels, ribs and nes, are then welded or riveted to the skin. The completed duct weighs 80 pounds and measures 102" long by 76" in the vature. Control of tolerance (cumulative tolerances are .005") is so highly developed at Ryan that these massive-earing access panels are interchangeable with any pod built a specific airline.

Where does titanium belong?

Titanium metal, built into the DC-8 as a basic design material, has been used in a variety of civilian and military applications in a direct volume-for-volume substitution for heavier materials to capture weight savings sufficient to permit improvements in systems or payload capacity.

Although such weight reduction programs and the attendant dollar value must be viewed in relation to the specific application, titanium's permanent resistance to atmospheric corrosion yields dividends immediately apparent to operators of commercial carriers. It means 8 to 10 trouble-free hours operation each day when maintenance means not only repair costs, but also downtime of expensive equipment.

In pods, pylons, landing gear doors, bulkheads, stringers, and a host of similar parts, titanium's weight savings are measured in *payback*. In projects such as solid and liquid propelled missiles, titanium's weight savings are measured in *payload*.

Why Titanium Metals Corporation of America?

Titanium Metals Corporation of America, the nation's only organization devoted exclusively to development, production and sale of titanium metal, has wide interest in establishing titanium metal only in those areas where it is of value to you.

The interest arises from the basic belief that a satisfied customer is a steady customer.

This interest is manifested in TMCA's genuine efforts to meet your delivery schedules; to provide you with whatever information you need concerning properties of titanium and manufacture of finished assemblies; and to pass on to you the price advantages gained through TMCA's technological progress.

Whether building new aircraft, or retrofitting operational ships, designing advanced missiles or modifying existing units, you can lick your weight bogey with titanium.

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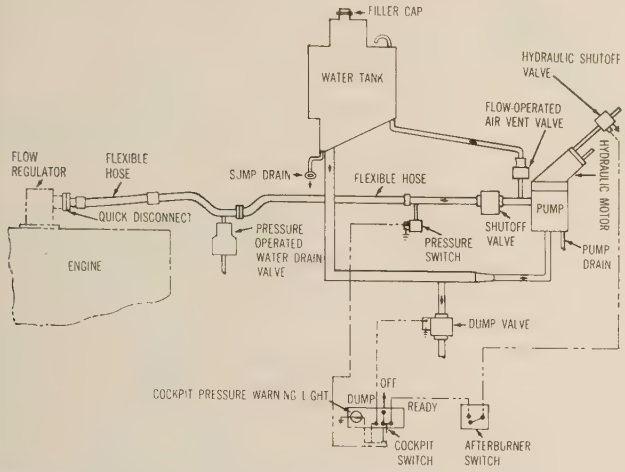
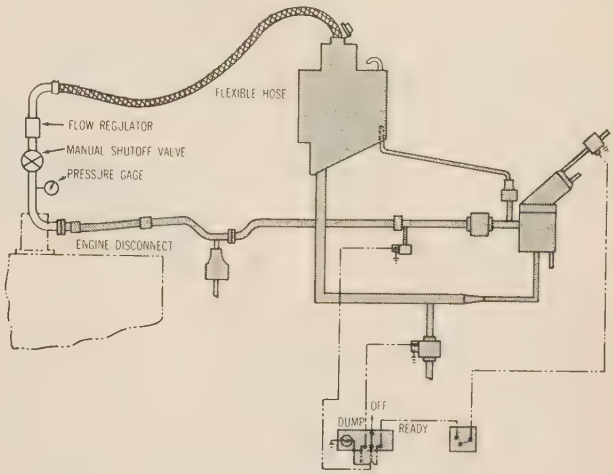


WATER INJECTION system used on F-105's P&WA J75 jet engine is designed to give extra ton of thrust.



GROUND SETUP for functional checkout of the F-105 water injection system.

Water injection

gives F-105 2000 lb extra thrust

The F-105 is the first production aircraft in which water injection is used in conjunction with the afterburner to boost takeoff and climb thrust. The injection system, which includes special ground servicing equipment, supplies 36 gal of water in one minute.

by Victor de Biasi, Associate Editor

WATER injection has given Republic's F-105 fighter bomber an extra ton of thrust. The F-105 is powered by a Pratt & Whitney Aircraft J75 jet engine, which has a rated thrust of over 24,000 lb with afterburner. The additional 2000-lb water boost thrust lasts just one minute—long enough for limited-runway takeoffs and fast climbs.

Water injection increases the thrust in two ways: (1) It adds its mass to that of the air and fuel going through the engine and, more importantly, (2) it cools the engine air flow, so that more fuel than usual can be burned without exceeding the temperature limitations. Basically, the airborne part of a water injection system consists of a hydraulic motor, a water pump, a water tank, valves, switches, and tubing. Since the system must be filled with demineralized water containing impurities of less than 10 parts per million, a portable ground supply unit is also needed to service the plane. Purified water can be stored in the aircraft for no more than 24 hours.

System operation is quite simple. All the pilot has to do is set

more on next page

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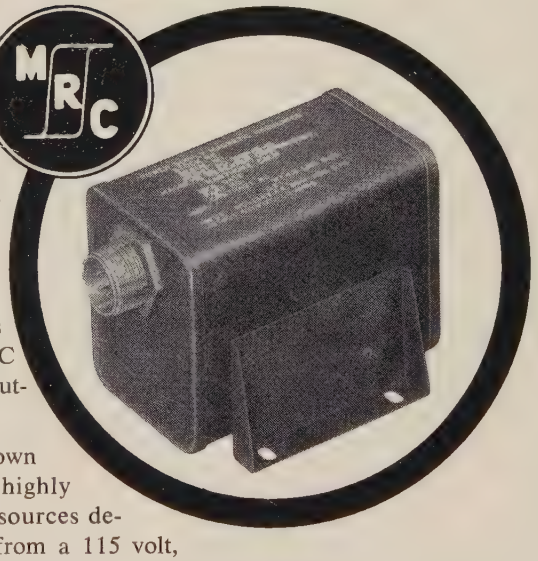
Students of alphabetology will recognize these letters to be "M.R.C." written in the magic alphabet. Engineers everywhere recognize MRC for quality, reliability and outstanding performance.



The airborne power supply shown below is one of a series of highly reliable stable power sources designed to operate from a 115 volt, 400 cycle line and supply well regulated and filtered DC power. Dual magnetic regulation, an exclusive feature of this series, supresses line transients and compensates for changes in load.

The use of magnetic amplifier circuitry with tantalum capacitors, silicon diodes and rectifiers...coupled with inherent short circuit protection...combine to achieve a degree of reliability unattainable in other types of circuits.

SPECIFICATIONS:

Model 40-103-0 is a typical 5 watt supply used extensively in missile instrumentation:

Input / 95-125 V; 380-420 cps
Output / 4.75 to 5.25 V DC (Adjustable), 0 to 1 amp
Regulation / ±0.1%
Ripple / 0.5% rms max. at full load

For additional information on MRC's complete line of airborne power supplies, write for Data File PS 1000.

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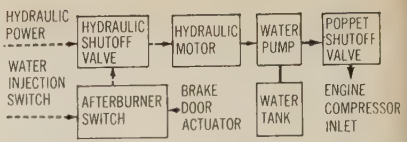


SIMPLIFIED schematic of operation for the F-105 water injection system.

the water injection switch to the "ready" position before takeoff. The system is now armed and ready.

When the speed brake doors open to the afterburner position during takeoff, a microswitch is actuated to energize the hydraulic shutoff valve in the water injection circuit. Hydraulic fluid flowing through the shutoff valve operates the hydraulic motor to drive an in-line water pump connected to the water tank. Water is pumped directly from the tank through a poppet shutoff valve to the engine compressor inlet.

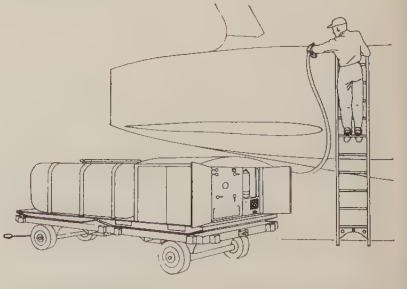
Limiter keeps the pump from overspeeding

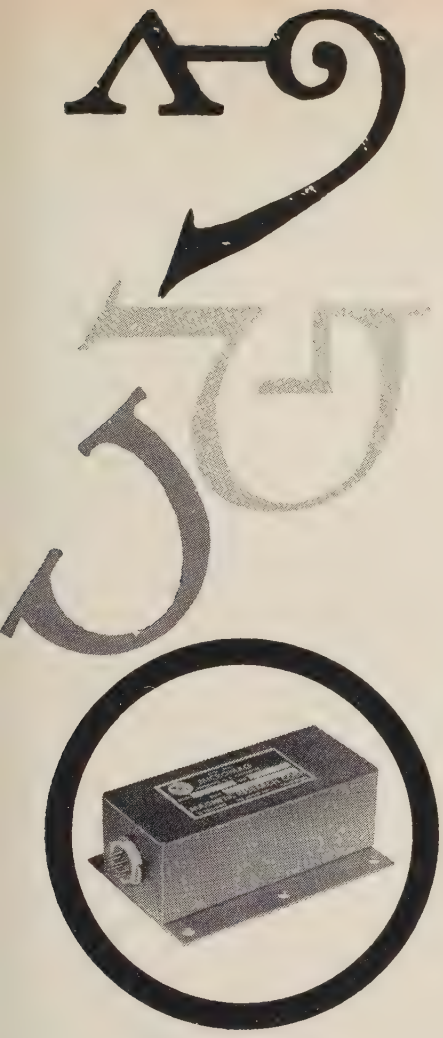
A flow limiter built into the hydraulic motor restricts the hydraulic supply to 8.1 gpm maximum. Normally, though, the motor operates with a maximum inlet pressure of 2650 psig and a flow of 7.15 gpm. The limiter keeps the pump from overspeeding when the water is depleted.

The water pump has a rated flow of 17,000 pph and a discharge pressure of 250 psig minimum and 270 psig maximum. As soon as the line pressure builds up to 110±10 psig the poppet shutoff valve cracks open to open the circuit to the engine.

Between the pump and the poppet valve is a ball check vent line that connects the pump discharge

GROUND SERVICE cart used with the F-105 water injection system.





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Typical Specifications:

Power / 26-31 volts DC, 10 milliamps
Input Signal / 0-10 millivolts DC
Voltage Gain / 500 ±10%
Output Load / 100 K ohms
Linearity / ±2%
Gain Stability / ±3% from 0°C to +65°C
Common Mode Rejection / At DC, 10^6
At 60 cps, 10^4
At 400 cps, 10^3

For additional information on MRC's complete line of Micromags, write for Data File No. MA1001.

MRC

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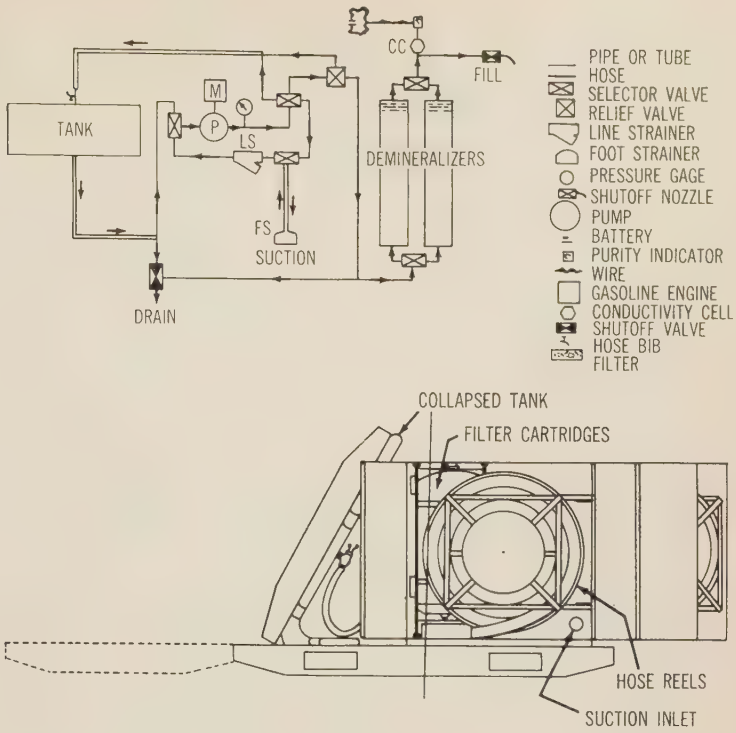


LAYOUT and configuration of the ground service cart.

with the tank. When the tank is filled with water, air is driven ahead of the water through the pump, the vent line, and back to the tank to eliminate air traps. During pump operation, the flow of water through the vent line seats the ball to restrict further flow through the vent.

Between the poppet valve and the engine is a spring-loaded ball-type check valve for automatic draining. The valve is closed when the system is under pressure. When pressure in the system is depleted, the spring-loaded ball unseats and opens a bleed line to the atmosphere. A solenoid-operated drain valve between tank and pump is actuated by a cockpit switch to dump any excess water.

Plane's tank must be filled in four minutes

One of the specs governing the operation of the water injection system is that the 38-gal tank in the plane must be filled with 36 gal of demineralized water within four minutes. The kicker is that the water might be drawn from muddy pools or streams.

Since there was no known equipment around that could do this job, Republic's engineers designed their own collapsible, trailer-mounted water injection servicing unit and demineralizer. It is air transportable and can deliver 10 gpm of demineralized water.

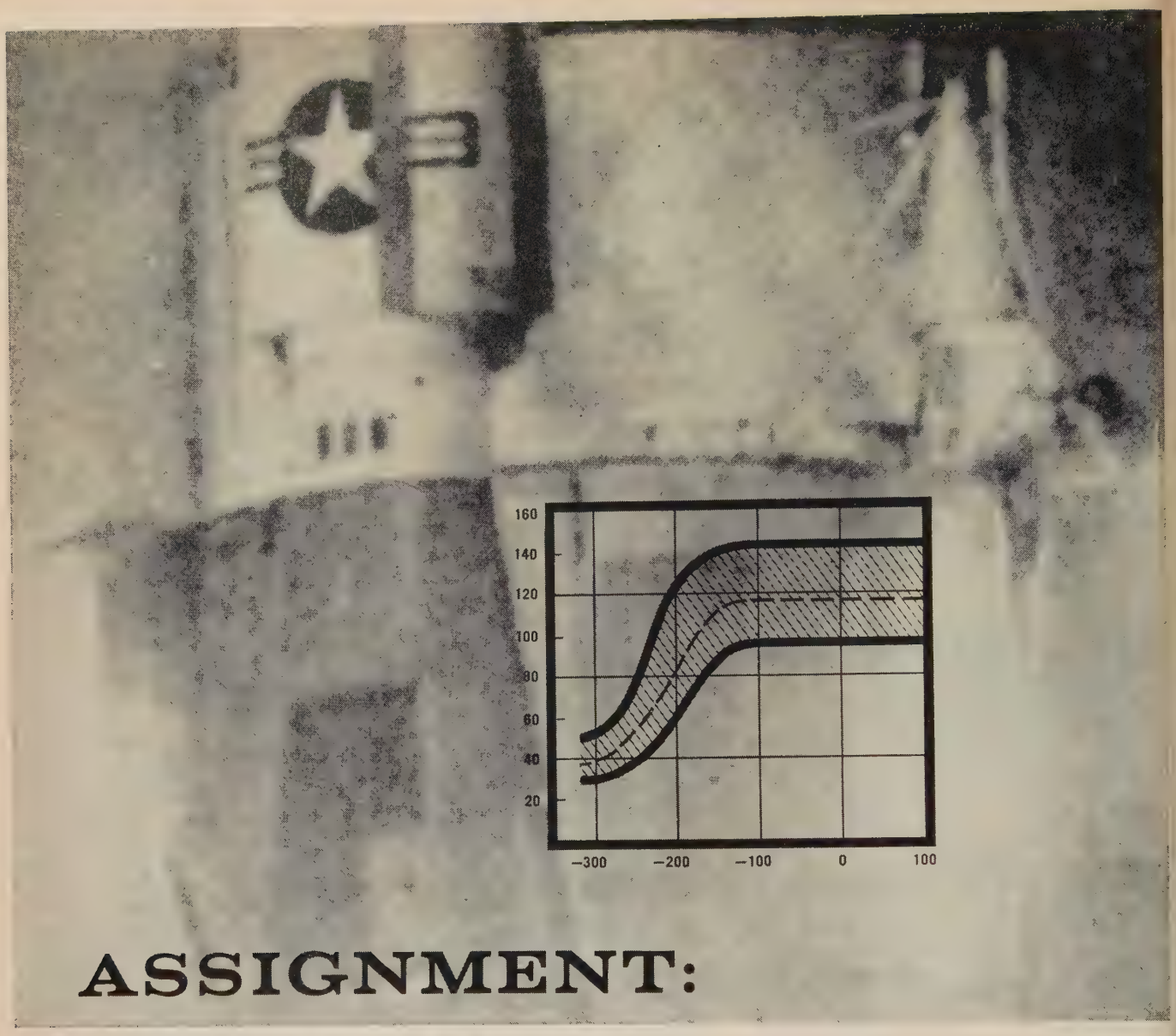
Basically, the ground servicing unit consists of a collapsible 250-gal water storage tank; demineralizer cartridges; a small, air-cooled gasoline engine; a water pump; hose reels; and controls. Raw water can be pumped into the storage tank at rate of about 20 gpm from a stream, river, or water tap. The pump, which does not have to be primed, can lift water from 20 ft below level.

Water supplied at 10 gpm minimum

When water is supplied to the plane, the raw water is pumped from the bottom of the tank through a demineralizing cartridge to the aircraft tank about 10 ft above ground. Cartridge pressure is controlled by a relief valve and bypass line.

Demineralized and filtered water with a total solid content of 10 parts per million or less is supplied to the plane at a minimum rate of 10 gpm. Two demineralizer cartridges are provided, but only one is used in operation—the other is a standby.

Water purity is registered by a conductivity meter on a control that is electrically connected to a conductivity cell probe in the water line. Power for the meter is supplied by a six-volt dry-cell battery.—End



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Missile components and liquefied gas tanks would be dangerously susceptible to cracking if made from ordinary steel. Seeking economical metals for such applications, Lukens engineers began years ago to watch the performance of nickel bearing alloys in a variety of low temperature equipment. Result: a broad understanding of metal behavior at various low temperature levels.

Examples: In the storage of liquefied oxygen, a tank of *Nine Nickel steel* provided more than eight years of trouble-free performance. Suitable to minus 320°F. service the steel showed no signs of cracking when removed for inspection. In frigid chambers for testing high altitude aircraft, *2½ percent nickel steel* is standing up well under pressures as high as 7,000,000 pounds. And in arctic locomotives operating at temperatures to minus 50°F. on rugged mountain roadbeds, main structures of *Lukens "T-1" Steel* have required no maintenance whatsoever.

Lukens Application Engineers know these cases . . . plus many more. *If your assignment is cryogenics, why not let it be our assignment, too?* Contact Manager, Application Engineering, K20 Services Building, Lukens Steel Company, Coatesville, Pa.

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ASK FOR LUKENS NINE NICKEL STEEL BULLETIN

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Bolt jams landing gear door mechanism

A SUPERSONIC jet pilot had to cancel his mission and return to base because a landing gear door had torn loose in flight. He landed safely without incident.* However, in other cases torn-off doors have caused fatalities and severe damage to aircraft structure.

Flight Safety Foundation, Inc., 468 4th Avenue, New York 16, N. Y., reports that the door broke away because the catching mechanism could not reach its full travel. Someone made an error in installing a bolt in the latching hook linkage, and as a result the shank of the bolt jammed against a hydraulic line fitting. The lever, to which it was attached, couldn't complete the latching cycle.

So little clearance was provided for the moving parts, Flight Safety Foundation engineers point out, that the difference between the length of the bolt head and the protruding shank caused the latch to malfunction.

*Directorate of Flight Safety Research, USAF, Norton AFB, Calif.

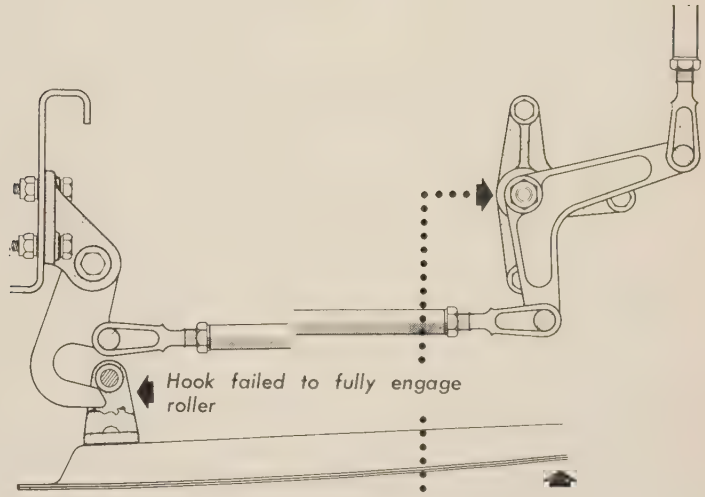


Fig. 1. Side View. Door Partially Closed.

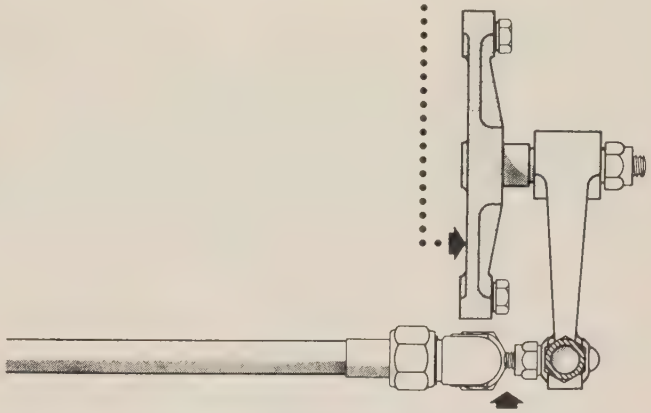
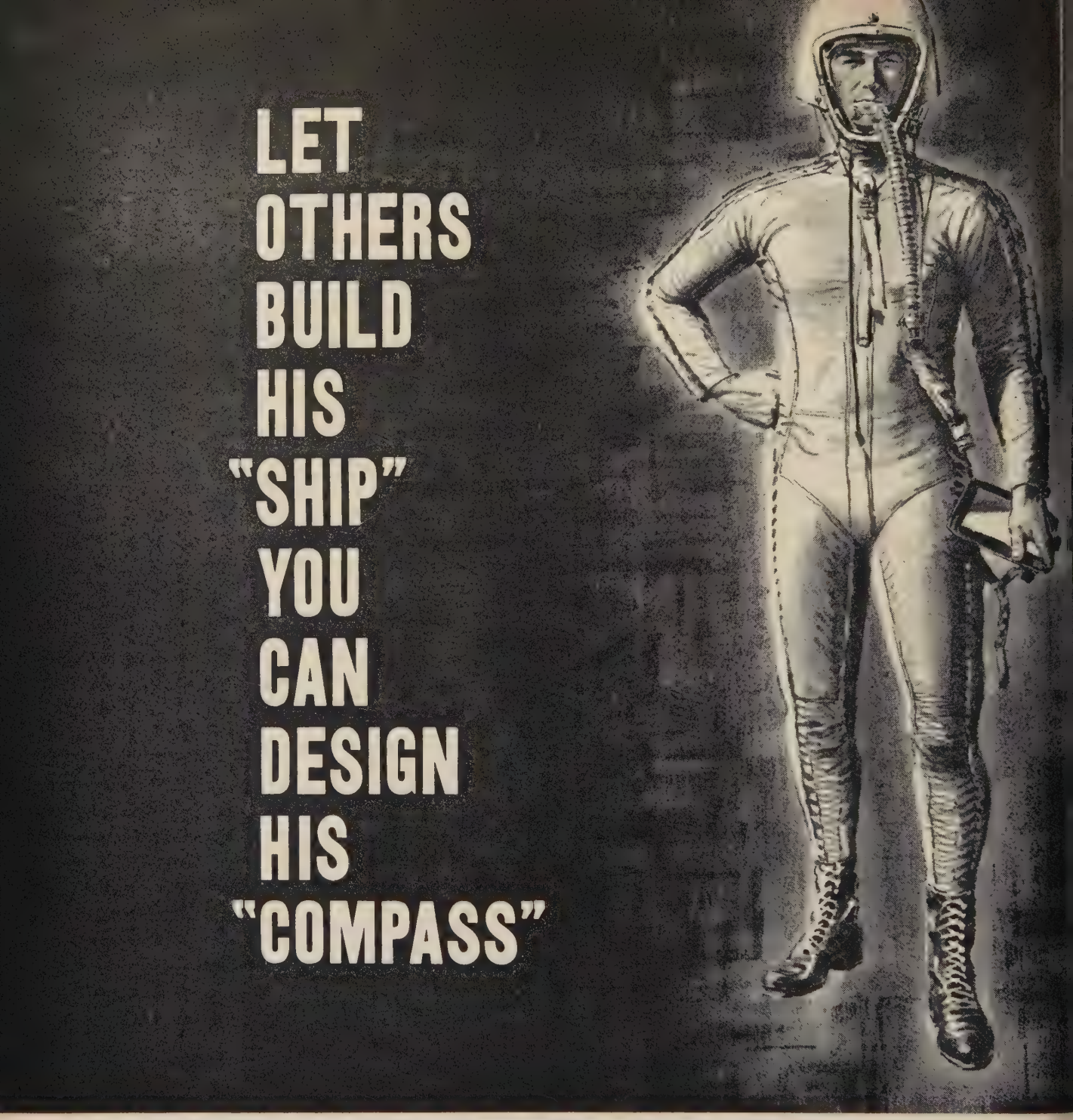

Bolt interfered with line fitting when installed as shown. Put in the opposite way, the head of the bolt cleared the fitting by a small margin.

Fig. 2. End View. Bolt Jammed Against Fitting.



Ryan, World Leader In Continuous Wave Doppler Navigation Systems, Has Urgent Need For Electronics Engineers

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Ryan Electronics has expanded dynamically until it now occupies over 375,000 square feet in two of Southern California's most ideal communities, San Diego and Torrance, providing year-round sunshine, the best housing, finest educational facilities for your children and advanced study opportunities for you. If you feel the course of **your** career has not been as direct as it might be, for full particulars, send your resume or write for a brochure to Ryan Electronics, Department 2, 5650 Kearney Mesa Road, San Diego 11, California.

RYAN ELECTRONICS

DIVISION OF RYAN AERONAUTICAL COMPANY, TORRANCE, CALIFORNIA, SAN DIEGO, CALIFORNIA

Check Employment Inquiry Form on Page 161

aerospace Electronics

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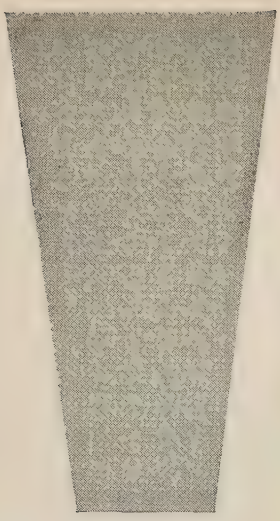

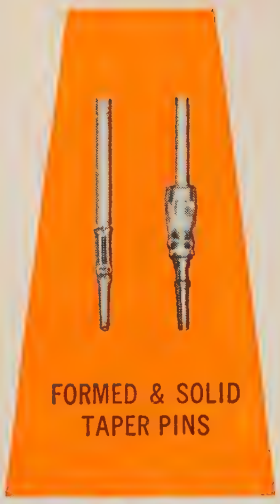

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The AMP Taper Technique offers the most complete line of taper products available plus many extra features. A three-and-a-half degree taper assures the firmest fit of pin in block. A-MP Pull-Test Insertion Tools assure the proper seating of pins. Hand and Automachine crimping tools assure uniformity of pin attachment to your circuit leads.

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You can concentrate more circuits in a smaller space—and be sure of reliability when you use the AMP Taper Technique. Send for our new catalog today.

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Track-while-scan system has 50-gate capacity

AUTOMATIC track-while-scan (TWS) system developed by Philco's Government Division makes possible continuous display of precise position of a radar-tracked target on a radar PPI while aircraft identity, velocity, heading, etc., appear on an air traffic controller's display. Targets are manually acquired with a joystick controller and are automatically tracked.

The TWS, says Philco, can track a target to minimum radar range, coast through the blind area surrounding the origin, and reacquire the target automatically as it recedes from the antenna. Operating range of the system is based on a 120-mile radar range. Accuracy is one per cent of total radar range.

PHILCO'S SYSTEM converts periodic radar position data on selected targets into continuous position and velocity data by means of tracking gates. By using transistorized circuits, the company gets 10 gates into a single, standard-size rack.

Capacity of the system is 50 gates. The system can be adapted to tracking targets from other sensors, such as infrared and sonar, says Philco.

Eight Vigilante systems to be tested by checkout unit

ELECTRONIC CHECKOUT equipment for Navy's A3J Vigilante attack bomber is being produced by Autonetics. First units have already been delivered.

One of the most advanced pieces of checkout gear made to date, this tape-reading, semi-automatic equipment will test the following systems on the Vigilante: flight control, navigation-bombing, master flight reference, radar altimeter, air data computer, electronic countermeasures, CNI (communications, navigation, and identification), and primary power.

•

IGNITRON MODULATORS will pulse BMEWS' radar transmitters. RCA, the prime contractor on BMEWS, selected GE GL-6228 ignitrons over hydrogen thyratrons, says GE, because of their ability to handle the extremely high average powers of the long range radars to be used in the early warning system. GE claims its GL-6228 will handle at least 50 times as much average power as the most powerful hydrogen thyratron. BMEWS is believed to represent the first use of ignitrons in advanced, long range radars.

"FIRST DIRECT digital readout scope" is Du Mont Labs' claim for its new oscilloscope. Basically a 35-mc instrument, it will be useful out to 60 mc; later versions are expected to handle signals varying at a 1000-mc rate. Its designers expect it will be possible to tie the new instrument directly into digital computers. Applications, Du Mont told SPACE/AERONAUTICS, will run from unskilled production line testing to the most advanced scientific studies.

NBS researchers simulate battle situations to find rules for target selection

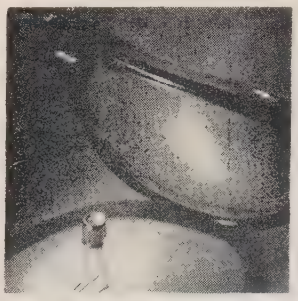
TARGET SELECTION rules for air defense weapons are being sought by National Bureau of Standards mathematicians for the Army Signal Corps. Using all relevant criteria involved in an actual air defense battle (nearness and velocity of attackers, type and number of weapons, etc.), NBS hopes to work out rules that determine which attackers should first be fired on. The effects of the criteria upon each other are what make the problem so difficult, says NBS. Experiments are now being run on a high speed digital computer that simulates the battle situation.

•

FAA TURNED thumbs down on Decca. After copter flight tests running from February to September last year, FAA concluded that "Decca Mk X navigational equipment did not meet requirements either for a primary IFR navigation aid or for an air navigation steering device . . ."

These conclusions are contained in a yet-to-be-released report entitled "Helicopter Operations Program, Phase I." The report is based on operational flight tests in a number of New York Airways copters on regular scheduled runs.

more on next page



Cover story — Tiny tunnel diode, often seen as the successor of the transistor in many applications, is beginning to reach industry. General Electric is offering lab samples like the one shown at $60 each. RCA, too, is offering several versions for industry evaluation.

According to FAA, tests showed that the Mk X's cockpit instrumentation doesn't fill the bill for aircraft steering—in addition to other factors, pilots were unable to maintain a constant heading of the aircraft without the aid of other instruments. Pilots, claims FAA, were also unable to change to a new course without referring to other aircraft instruments.

FAA FOUND that, on 61 per cent of the test routes, pilots reported that equipment failed to give enough navigation intelligence for continuous IFR flight. Major drawbacks of Decca Mk X, according to FAA, included:

- The system was subject to tracking pen deviations on the flight log. In this way, wrong information was given to the pilot.
- Without a preprinted course, a pilot lacked the position accuracy required for holding and for homing between fixes.
- The system was subject to losses of zone identification in intermediate ranges at which satisfactory coverage had been expected.
- On instrument approaches, the system was at best comparable to an ADF letdown (a relatively unprecise approach, normally resorted to only when conventional ILAS gear is inoperative). In the Boston, Mass., area, position information from the Mk X could not be used for instrument approach.

Decca controls were often hard to work, pilots reported in route test

FAA'S REPORT also mentions a number of other shortcomings of the system, including the fact that pilots found that, on 22 per cent of the routes, manipulation of the controls was relatively cumbersome. The Decca system was tested over four carefully selected routes. Checks involved holding patterns, homing, operational compatibility with existing air traffic control systems, tracking, flight log chart management, coverage of various charts, and the degree to which the pilot could stay within the 10-mile-wide airway bounds.

While the tests were made ostensibly to evaluate Decca as a helicopter navaid, the report implicitly condemns the Mk X as a navaid and steering device for any aircraft. FAA did not make it clear how it could draw this implication from copter tests alone.

LOOK FOR the British to raise a vigorous protest through the International Civil Aviation Organization, in what may be the final round of the long feud between Decca and VOR-DME partisans. The British apparently have been holding back with their views on the controversy pending the results of FAA's test program.

■

MINIATURE DATA PRINTER developed at New York University's Research Division is smaller than a pack of cigarettes and weighs only a few ounces. Printing is done on electrosensitive paper by energizing elements of an array of stainless steel printing segments. The tiny unit can print up to 20 digits simultaneously.

Because it uses very little power, the printer can record directly from the outputs of most electronic devices, doing away with isolation and driver stages, says NYU.

Three-kc hydro-acoustic transducer puts out three kw, Stromberg-Carlson reports

INTERESTING hydro-acoustic transducer is being developed by Stromberg-Carlson. It converts fluid flow under 1500-psi pressure to acoustic energy. Power handling capability varies inversely with the square of the frequency.

A three-kilocycle unit built by SC hydro-acoustic researchers puts out three kilowatts of acoustic power. Its diameter is six inches; weight is about 50 lb.

■

THE ADVANTAGES of the hydro-acoustic unit over magneto-strictive and ceramic transducer types are high power operation per unit weight and low cost per kilowatt of acoustic power.

According to SC's hydro-acoustic engineers, the transducers are self-excited oscillators in which positive acoustic feedback is applied to a pressure-actuated flow control mechanism. This mechanism acts as a switch that converts steady flow energy from a hydraulic source to a variational flow that is stored in an acoustically resonant circuit. Part of the stored energy is fed back to sustain oscillation; the remainder is conveyed to the external load.

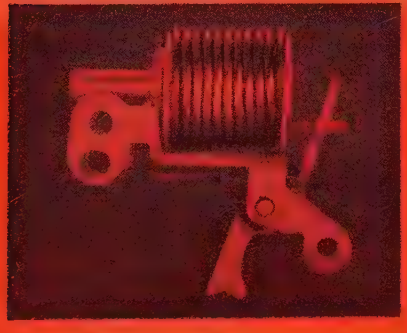
■

SIX EVALUATION prototypes of an advanced, highly miniaturized air data display system will be developed by Minneapolis-Honeywell's Aeronautical Division under a WADC contract. The new system, which will be used in WADC's integrated flight instrument panel for high perform-

more on page 130

NO HIGH-AMBIENT DE-RATING!

HEINEMANN CIRCUIT BREAKERS HOLD THEIR RATING AND TRIP POINTS AT ANY TEMPERATURE



Here you see the overload-sensing element of a Heinemann circuit breaker. Its unique type of magnetic actuation is functionally independent of temperature effect. Operation is based on actual load current —not on current-produced heat, as is the case with thermal-type devices. Consequently: current ratings hold constant at 100% nominal value, set trip-points stay fixed at specified overload percentages regardless of the ambient. Performance is always predictable, consistently dependable. Think about it: wouldn't your equipment gain added reliability with such built-in, temperature-stable protection? The Heinemann *Circuit Breaker Engineering Guide*, Bulletin 201, has all the technical details you'll want to know. Write for a copy.

HEINEMANN ELECTRIC COMPANY 170 PLUM ST., TRENTON 2, N.J.

Write in No. 92 on Reader Service Card at start of Product Preview Section

ance aircraft, consists of two units that crank out 14 information displays for the pilot. In addition to conventional information, Honeywell's new display instruments will include a takeoff monitor and terrain clearance display. A size reduction of about 40 per cent over the present state of the art and a 50 per cent cut in power consumption are written into the contract.

POWER FAILURE in a spacecraft may mean that the human aboard will have to crank out the emergency power himself, says Ezra S. Krendel, of Franklin Institute's Psychology Branch. The use of manpower reserves, Krendel notes, would save the weight and space of power-storing batteries. Standby emergency devices such as hand-cranked or foot-pedalled generators are being considered, he adds.

FOLLOW-ON AWARDS of more than $1,300,000 were received by Summers Gyro from Martin-Orlando for spring-wound gyros for the Bullpup. Ironic point is that Bullpup's outstanding marksmanship record was achieved with what reportedly is the industry's cheapest gyro.

New spin-casting process is claimed to give very close parabolic surfaces

RADAR "MIRRORS" with exceptionally accurate parabolic surfaces are claimed by D. S. Kennedy, antenna manufacturer, as the product of a new spin-casting process using the principle that the surface of a liquid will curve into the shape of a near-perfect paraboloid when the liquid container is rotated about an axis at constant speed. The process involves coating the surface of the radar dish with a liquid synthetic resin. Applied while the antenna is spinning on its axis, the liquid solidifies in a few hours.

The reflector surface can have an almost glass-like smoothness, say Kennedy engineers. Surface characteristics 1000 times more accurate than any attained with conventional reflector production are possible, they claim.

■

SOME OF THE BENEFITS expected from the new process should be more efficient use of RF power and the ability to receive and transmit at much higher frequencies than are now practical. To date, Kennedy has developed a four-foot feasibility model and is working on a 10-ft model. It hopes to start work on 60-ft dishes in the near future.

According to Kennedy engineers, in theory there is no limit on the size of a spin-cast antenna. The practical limit would be imposed by our ability to build stable rotating tables on which to spin huge paraboloids.

The idea of adapting spin-casting to antenna production occurred to Kennedy after it had learned of the work of Paul B. Archibald at the University of California's Radiation Lab. Archibald has been using this technique to spin plastic optical mirrors for light-gathering studies sponsored by AEC.

Grease pencils and plotters beat B-52 ECM gear

REVERSING THE TREND to highly electronified display and computing equipment in air defense control centers, the Mantrac (or *M*anual *An*gle *Trac*king) system developed by Boeing's Aero-Space Division may provide an accurate yet inexpensive method of tracking and intercepting airborne weapons in areas where Sage or other electronic complexes are not available (or wiped out?). Based on the simple mathematical position-finding technique of triangulation, its operation is concentrated on a large plexiglas map of the area to be defended. The latter is defined by grid lines and codes describing separate land zones served by radar installations. With direct telephone links to the radar sites, plotters enter the compass bearings of attacking vehicles as called in at precise intervals.

WHEN ENOUGH data points have been entered, an operator can determine the radar's course, altitude (since he knows the distance between consecutive sites and the tracking angles), and speed (by correlating time with distance traversed). Geographical position has already been plotted on the board. Battle commands are then transmitted by phone to area defenders.

Boeing engineers say the method is proof against electronic countermeasures and jamming —as was demonstrated in test raids made against it by B-52s vainly using the whole bag of ECM tricks against the men with the grease pencils and plotters.

■

GALLIUM PHOSPHIDE, a rare metal that withstands temperatures of up to 1500 deg F, may help solve the heat resistance problems of electronics in missile and spacecraft nose cones, reports Brig. Gen. J. C. Monahan, chief of the Army Signal Corps' R&D Division. The material

more on page 132

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Monahan notes, could be used in making solar-cell powerplants for space stations or as a rugged core of tiny electronic devices for space electronics.

Gallium phosphide is made up of two chemical elements which, when apart, melt at low temperatures. Gallium, which runs about $1500 the ounce in pure form, melts in the hand; phosphorus melts in the sun.

RESEMBLING yellow ground glass, the material was home-grown in the R&D Lab at Fort Monmouth, N.J. Lab scientists used it in devising an experimental diode. On the basis of early performance analyses, they believe ultra-high-temperature switching devices based on the new material are not far off.

The Signal Corps is winding up a study designed to pin-point the material's unique properties before actually undertaking the development of electronic hardware.

A COMPLETELY transistorized fire control instrument that will control Astor — one of the Navy's latest ASW torpedoes — is being developed at Sperry Gyroscope. Called the Mark 18 angle solver, it's being built under a $2.5 million award from Westinghouse, developer of the long range, wire-guide torpedo.

Philco Filterscan uses invisible infrared emission

SCIENTISTS at Philco's Research Division perfected a method of electronically reproducing an image of heat-emissive targets detected by cells sensitive to the invisible IR portion of the light spectrum. The "Filterscan" system gives good picture quality with a TV-type image presented in a 150-line raster. According to Philco engineers, higher scan rates could be used where the application requires higher definition. Electronic scan, they add, is some 30 times faster than mechanical scan and lets you monitor rapid changes in the direction or heat intensity of the target much more closely.

SECURITY WRAPS veil the possible military uses of Filterscan, but one could guess that it might well fit into the anti-ICBM missile picture.

•

AN INERTIAL reference system of the type used in Polaris-carrying subs has been ordered by USAF to aid in the flight-testing of the Army's Pershing missile. Autonetics reports that one of its SINS systems is to be delivered to Patrick AFB, Fla., for installation aboard an Atlantic Missile Range tracking ship to enable the latter to track the bird down range. Despite ship motions, the inertial system will provide the attitude reference required to compute the missile's deviation from its prescribed course at any point.

EIGHTY-FIVE DAYS after launch, Vanguard III's silver-zinc-battery-powered transmitters died, just five days short of the nominal lifetime predicted for them. NASA scientists report that telemetry records from the satellite, which orbited earth 938 times during its transmitting life, are still in the early stages of processing and analysis. They feel confident that the various experiments—measurement of the earth's magnetic field, solar X-ray radiation, and space environment conditions—were successful.

BMEWS work is on schedule, says Gen. Sarnoff

RADAR ALARM NET being set up in the far north is moving ahead right on schedule, says Gen. David Sarnoff, chairman of RCA, BMEWS prime contractor. Construction at one of the three planned sites is about 90 per cent complete and at another is 50 per cent finished, he adds.

Going along with our work on detecting the approach of enemy missiles in time to defend ourselves against them will be the development of an effective anti-missile—a goal that Sarnoff expects will be attained in the present decade. In the next five years, Sarnoff predicts, the overall annual electronics business will hit $25-billion —$11 billion over the '59 figure. Much of this growth could depend on government support of large-scale missile detection systems.

•

RADAR SYSTEMS that can provide three-dimensional warning information six hours after air delivery to their sites will be built by Westinghouse under a $15 million contract with the Rome (N.Y.) Air Materiel Area. The design calls for a complete system, including auxiliary equipments and shelters, that can be transported by copter. According to Westinghouse's Electronics Div., the system will use a 30-ft ellipsoid paraballoon antenna weighing about 2200 lb. Only one crew will be needed to operate it for 24 hours, he adds, though previous systems needed two crews.

THOMAS A.

EDISON

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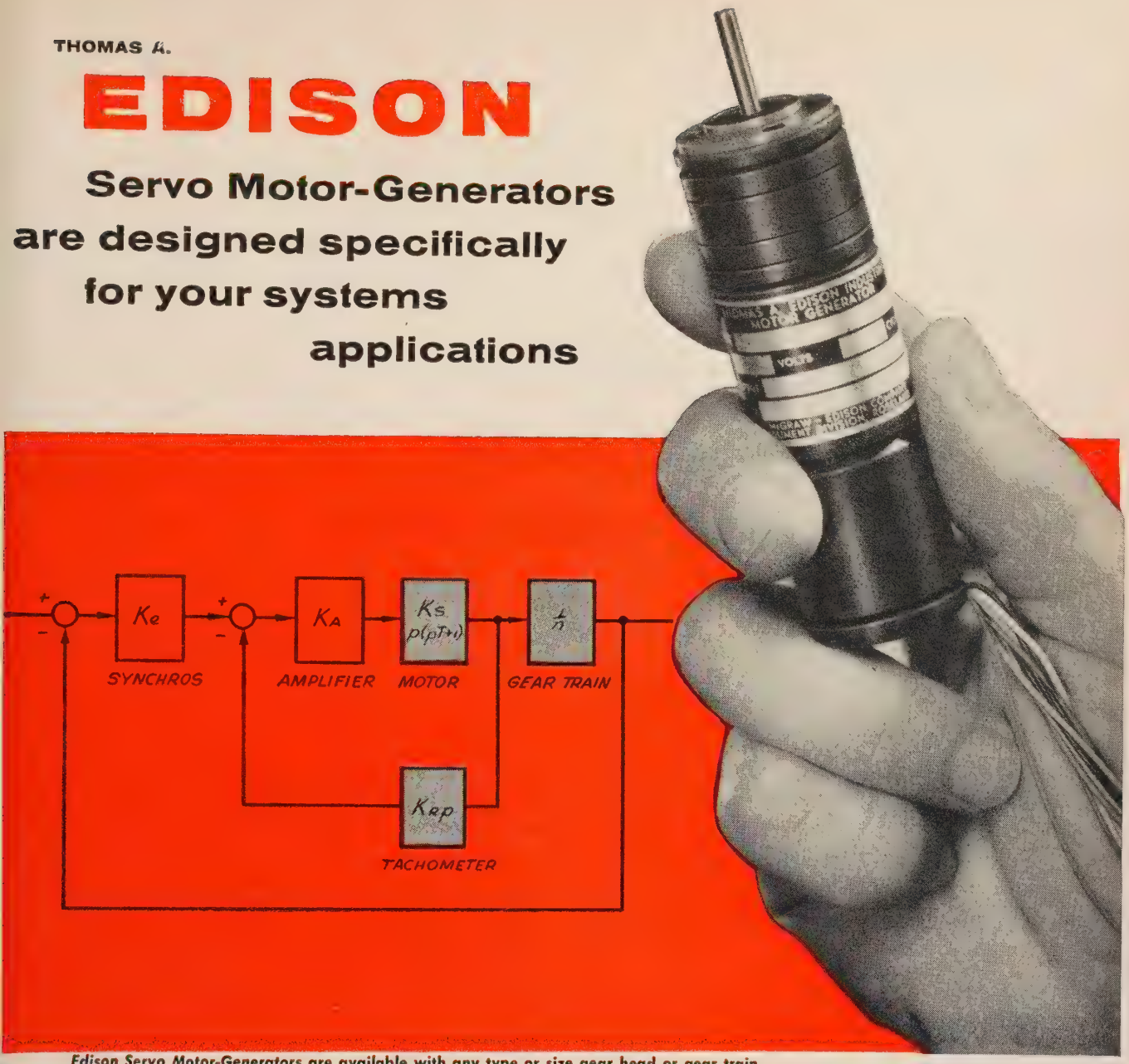

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In addition to these special system features, Edison Servo Motor-Generators are made to the highest quality standards. They outperform MIL-S-17087 (for motors) and MIL-S-17806 (for generators).

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Industry pushes work on

low altitude radar altimeter

Like the man who builds a better mousetrap, the group that can make an accurate, light, and cheap low altitude radar altimeter will not suffer from lack of customers. Today no such instrument is being produced, but it looks as though we will have more than one model before the end of the year.

by James Holahan, Electronics Editor

WANTED by U.S. military and FAA; Low-level and flareout absolute altimeter for measuring height from about 1000 ft to ground level with an accuracy of 2-3 ft or three per cent of altitude (whichever is greater). Cost should be around $5000; weight should be under 25 lb.

Purpose: Primarily for instrument landing of fixed wing aircraft; also low-level operation and landing of helicopters and VTOL aircraft. Other important applications: low-level navigation and bombing, surveillance drones, anti-submarine warfare (ASW) aircraft carrying "dunk-sonar", and, eventually, soft landings on the moon and planets. (Because of conflicting requirements, specific designs might have to be developed for these applications.)

Potential Market: For instrument landing (should the system finally settled on by FAA and the military include a radar altimeter, as appears likely)—at least 20,000 units, or $100 million; for helicopters and VTOL craft—at least 1000 units, or $5 million; for ASW—3000 units, or $15 million; for space—unknown.

Available Equipment: None.

This brief rundown just about describes the present state of affairs in low-level, absolute-reading altimetry. The "no equipment available" tag shouldn't stand much longer, however. Several promising projects are underway in the aerospace electronics industry; and at least two, and possibly four, altimeters meeting the specs we have outlined should become available in production quantities this year.

Perhaps the most explicit requirements for a low-altitude and flareout altimeter were set down by the Blind Landing Experimental Unit (BLEU) of the British Royal Aircraft Establishment. BLEU probably has accumulated more experience in instrument development and testing than any other group in the world today. Here's what it is looking for in an absolute altimeter:

- height accuracy of about two feet close to the ground, as well as a smooth height-derivative (dh/dt) output;
- a short time constant of 0.1 seconds, so that no excessive lag will build up in the servo loop;
- output linear with height;
- drift of the zero datum of less than one foot under all circumstances.

Only two existing altimeters are known to approach these specs: Standard Telephones & Cables' STR-30-B1 and Emerson Radio & Phonograph's modified APN-100. Both are FM-CW types operating in the 4.2-4.4-mc altimeter band. STC is an English affiliate of International Telephone & Telegraph. Its STR-30-B1 has actually met BLEU's specs in flight tests, BLEU states.

The STR-30-B1 is accurate to ± 3 ft or three per cent (whichever is greater) at low levels. At touchdown its error will not be greater than one foot, the company reports. BLEU is using the unit in its experimental system, and FAA has bought two for testing.

The big drawback of the STR-30-B1 is its weight.

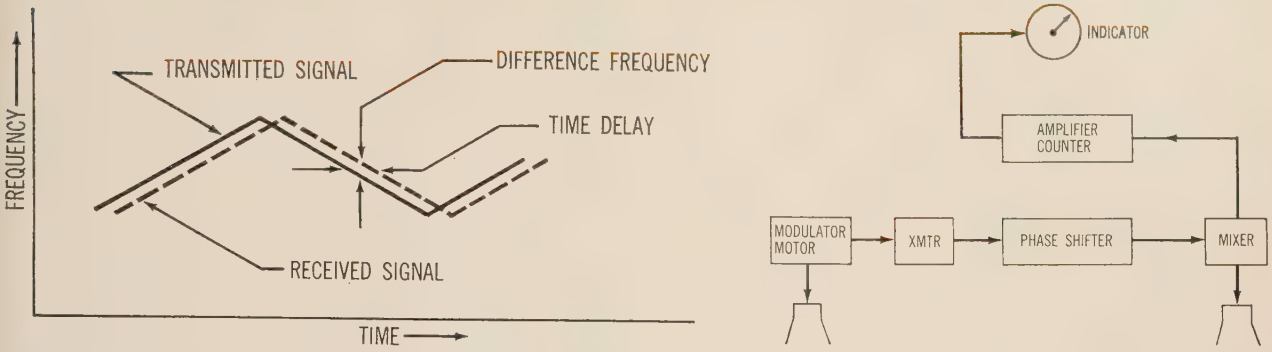

FIGURE 1: Operation (left) of an FM-CW radar altimeter. Right: An "unquantized" FM radar altimeter. Temporary phase coherence is eliminated between the heterodyned height signal and the sweep waveform.

At 45-50 lb, it's just about twice what it should be. The trouble lies mainly in design that is obsolete by today's standards—25 vacuum tubes with non-miniature circuitry are used. A modern version of the 30-B1, the STC Mk-7, is now in service test (*Fig. 2*). Weighing 20-30 lb, it consists of a vacuum-tube "hot box" (transmitter-receiver) and a transistorized "cold box" (frequency counter). Production of the Mk-7 is planned for this year.

STC has already proposed a radar altimeter characteristic to Aeronautical Radio for adoption by the U.S. airlines. It suggests an 8-12-lb FM-CW altimeter tailored, not surprisingly, according to its special design philosophies. In this way, STC apparently would tie down the operating principle of the altimeter quite tightly—at a point in the development cycle that appears to be too early for the airlines or any other group to settle on any specific design principle.

The closest U.S. rival of STC's altimeters is Emerson's APN-100, developed for the Army Signal Corps. This unit is undergoing qualification tests at Emerson. A modified version, based on the APN-100 but designed expressly for flareout, has been built for Autonetics' APN-114 instrument landing system, soon to be evaluated by USAF and FAA. This version, according to Emerson, exceeds the BLEU specs. Its height and height rate outputs are linear 400-cycle voltages. (In the APN-100, h and dh/dt are logarithmic functions of the output voltage.)

A recent study by Airborne Instruments Lab for FAA of the "state of the art and equipment availability" for low-altitude and flareout altimeters shows eight more designs, six of which are in the works and two of which are available (see *Table*). These last two apparently are not suitable for flareout: Sylvania's APN-117, a low-level version of the present military standard APN-22, is reportedly unstable below five feet, and the AM-220H, developed by France's Co. de Télégraphie sans Fil (CSF), has an accuracy of only ±10 ft or 10 per cent of height (whichever is greater). The Navy is said to be interested in the AM-220H for ASW aircraft. There's a strong possibility the set will be produced by CSF's U.S. affiliate, Intercontinental Electronics. It is being tested in a New York Airways helicopter.

Some interesting conclusions were reached by AIL in its appraisal of the state of the art on absolute altimetry:

- "A flareout altimeter must be expressly designed for that purpose. Modifications or repackaging of terrain clearance equipment cannot be successful, nor can the function of a flareout altimeter be successfully combined with that of obstacle warning or other functions."
- " . . . quantized FM-CW techniques can meet the present low-altitude and flareout requirements. By 1960, there will be a choice of equipments."

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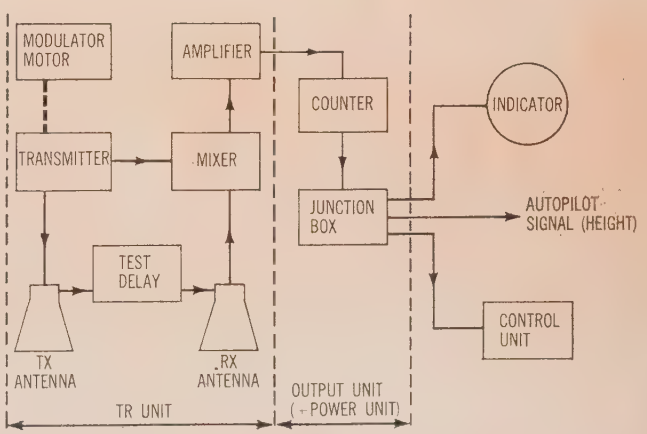

FIGURE 2: FM-CW radar altimeter developed by Standard Telephones & Cables. Carrier frequency is 4300 mc; modulator frequency, 300 cps; output time constant, 0.1 seconds. The altimeter has two ranges: zero to 5000 and zero to 500 ft.

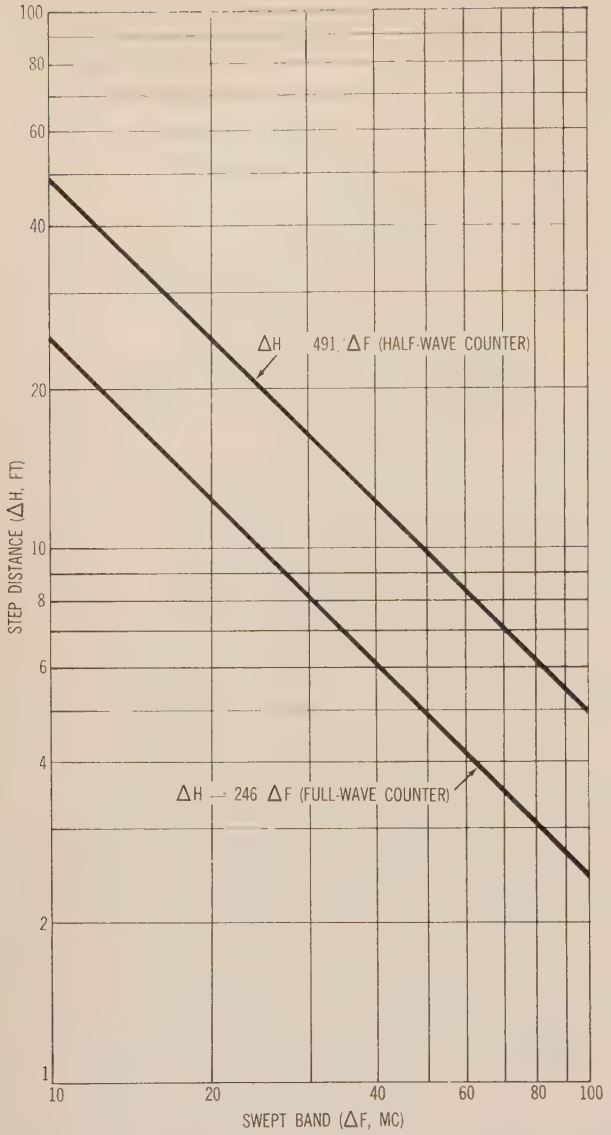

FIGURE 3: Step distance vs swept band for peak-to-peak deviation in a clipping-counter-type FM-CW altimeter. Step distance is halved by using a full-wave instead of a half-wave counter.

- "With the likelihood of higher accuracy requirements in the future, it is probable that non-quantized CW altimeters will be used more extensively . . . this equipment will be phased into service by the end of 1960."
- "[The] capabilities of pulse-radar altimeters may later prove attractive. Present development shows a high degree high accuracy possible with lightweight equipment. There is also a possibility that pulse-radar altimeters could combine flareout with terrain clearance or obstacle warning, without the usual disadvantage of such combinations."
- Sonic altimeters are not likely to be universally applicable.

So far absolute measurement of low altitudes has been the job of FM-CW designs and high-altitude measurement that of pulse types. The latter would need very short pulse lengths to measure a few feet of altitude. (To measure five feet, the round trip travel time of a pulse would have to be 10 millimicroseconds.) Short pulselengths naturally mean large bandwidths (on the order of 100-200 mc) and therefore large equipment.

In the FM-CW type the meaningful information is an audio beat frequency that is processed with narrow-band circuits. A rough estimate shows that a low-altitude pulse altimeter would have to be 2-3 times larger than an FM-CW type (assuming, of course, that the same frequency band and conventional design approaches are used).

One could get away from very short pulses in a pulse altimeter by using some specific point of the pulse (e.g., the leading edge) as the timing point. However, this approach, too, would lead to complexity and large size if high accuracy (e.g., ±3 ft) were required.

The FM-CW altimeter measures height by comparing the frequency of transmitted-signal returns with the instantaneous transmitter frequency (*Fig. 1*). Since the frequency change is made either a linear or a sinusoidal function of time, this frequency difference is proportional to the time it takes the signal to travel from the aircraft to the ground (or sea) and return. The rate of travel being a constant (the speed of light), the frequency difference is proportional to height. In the linear-modulation case, the relationship is:

$$H = f_d c/(4df/dt),$$

where H is measured height; f_d, frequency difference between direct and reflected waves; c, speed of light; and df/dt, rate of change of frequency.

The frequency comparison is made by feeding the direct signal (coming directly from the transmitter) and the reflected signal (returned from the earth's surface) into a mixer whose output is the difference frequency, an audio beat not equal to f_d. Actually the beat frequency output is not a single frequency. As explained by M. P. G. Capelli, of STC, "frequently df/dt is not linear, and therefore f_d is not a discrete frequency but a whole band of frequencies governed by the variation of df/dt over a sweep cycle".

Because a frequency spectrum is actually detected, most FM-CW designs use a clipper-counter-type circuit to extract an average current that is proportoinal to height.

Step distance and step error

A Fourier anlyasis of this arrangement shows that the mixer output can be only a frequency that is an integral multiple of the sweep frequency. Altimeters with this characteristic are called "quantized" (*Fig. 3*) and are limited to a height resolution equal to the distance represented by one sweep cycle, or the "step distance". In turn, this distance is inversely proportional to the total deviation, or "swept band". It equals:

$$H_{step} = \pm c/4\Delta f.$$

To "plug in" some numbers, assume a swept band of 100 mc. This gives a step distance of ±2.5 ft for a radio wave travel of 1000 ft/usec. Now if the sweep rate were 100 cps and the output of the mixer also 100 cps (one times the sweep frequency), this would indicate an altitude between zero and five feet. A 200-cps output (twice the sweep frequency) would indicate an altitude between five and ten feet.

A "step error" occurs because the clipper-type cycle counter counts the average number of zero crossings of the audio wave. Because of the length of the propogation path, there will be, of course, a phase difference between direct and reflected waves. Since the phase of

more on page 138

Altimeters for Low-Altitude and Flareout Use

Designation	AN/APN-94	AN/APN-100	AN/APN-117	AM 220H	30 BL	Mk-7	705A			Sonic	
Manufacturer	Raytheon Co., Foundry Ave., Waltham 54, Mass.	Emerson Electric Co., 8100 Florissant Ave., St. Louis 36, Mo.	Sylvania Electronics Systems, 63 Second Ave., Waltham 54, Mass.	C. G. de Telegraphie sans Fil, 79 Blvd. Haussmann, Paris 8, France	Standard Telephone & Cables, Oakleigh Rd., New Southgate, London N. 11, England	Standard Telephone & Cables	Sylvania	Laboratory for Electronics, 1079 Commonwealth Ave., Boston, Mass.	Sanders Assoc., Inc. 95 Canal St., Nashua, N. H.	Bendix Aircraft Corp., Bendix-Pacific Div., 11600 Sherman Way., North Hollywood, Calif.	Sylvania
Type	FM-CW, flareout, 0-100 ft, 4250-4350 mc	AM-FM-CW, low altitude, terrain clearance, 0-3000 ft, 4250-4350 mc	FM-CW, low altitude, terrain clearance, 0-100 ft, 4200-4400 mc	FM-CW, low altitude, terrain clearance, 0-1000 ft, 1600-1660 mc	FM-CW, flareout, 0-500 ft, terrain clearance, 0-5000 ft, 4200-4400 mc	FM-CW flareout, 0-500 ft, terrain clearance, 0-5000 ft, 4200-4400 mc	FM-CW, low altitude, general purpose, 0-1000 ft, 4200-4400 mc	phase-CW, low altitude, general purpose, 0-1000 ft 4200-4400 mc	FM-CW, low altitude, general purpose, 0-2000 ft	sonic-pulse, low altitude, general purpose, 0-3 kc	FM-CW, low altitude general purpose, 0-3000 ft, ~4300 mc
Sponsor	USAF	USA	none	French navy & air force	RAE	RAE	USN	none	USN	none	USN
Availability	breadboard only	production '60	from stock	6-month delivery	limited quantities, 1-month delivery	production early '60	production early '60	production est. late '60	1-2 years	as required	1 year est.
Cost		$15,-20,000 (approx.)	$4000	$5200-8500	$4550	$4550 (approx.)	$4000 (approx.)			$1500	$1500
Weight (lb)	20	20	32-5	20	45-50	20-30	18	15-20	4	12.5	9
Size (cu. in.)	250	600	1600		2330		700	864	86	600	450
Accuracy	±2 ft or 3%	±2 ft or 2%	±2 ft or 5%	±10 ft or 10%	± 3 ft or 3%, not to exceed ±1 ft at touchdown	±3 ft or 3%, not to exceed ±1 ft at touchdown	±2 ft or 5%	±1 ft or 3%	within 5 ft or 5%, later version within 1 ft	±0.5 ft or 5%	±2 ft or 5%
Output	dc voltage linear 0-1000 ft	dc voltage logarithmic	dc voltage semi-logarithmic	dc voltage linear	dc voltage linear, 0-500 & 0-5000 ft	dc current linear, 0-500 & 0-5000 ft	dc voltage semi-logarithmic	dc voltage linear	400-cps ac or dc voltage linear	logarithmic	dc voltage semi-logarithmic
Rate of descent	yes	yes	no	no	yes	yes	no	yes	if required	no	no
Safety Features		flag warning & servo to 0 ft	pointer behind mask	pointer servos to 0 ft	flag warning & confidence check	flag warning & confidence check	pointer behind mask	yes (exact type not settled)	yes (exact type not settled)	no signal with amber light on	pointer behind mask none
Low Altitude Flight Tests	WADC in near future	limited, inconclusive so far	various, limited	limited & inconclusive	extensive, over 4000 automatic landings	believed to be under test	limited to date, to be completed	some breadboard components tested	none	in various rotary & fixed wing aircraft	
Operational Limits	1000 fps, track rate limit	±20° pitch, ±30° roll	±30° pitch & roll, altitude/5 fps track rate limit	±40° pitch & roll	±17° pitch, ±20° roll	±17° pitch, ±20° roll	±30° pitch & roll	±25° pitch & roll approx.		±25° pitch & roll, speeds up to 150 knots	±30° pitch & roll
Remarks	highly developed version of AN/APN-22; new magnetron, electronic servo & transistors	transistorized, very rugged, hard mounting; commercial version with tubes $8000-10,000; to be used in AN/APN-114 landing system	low altitude version of AN/APN-22, used primarily in copters	in service with French & Swedish air forces	developed for BLEU landing system; also tested by British Ministry of Transport & Civil Aviation, to be tested at WADC	transistorized lightweight version of STR 30 B1	completely interchangeable with AN/APN-22 & -117; subminiature version of AN/APN-117	transistorized	miniaturized 1x3-in. antenna units	development of new type of transducers is proceeding	transistorized version of Sylvania 705A

the audio beat signal at the start of each modulation cycle depends on this phase difference, the counter can see one more crossing of the zero axis or one crossing less. Thus it can count one apparent cycle more or less and be in error by an amount equal to the step distance. In fact, at some time during a relative phase shift of 90 deg, a "cycle" is added or deleted.

The error can change in sign quite rapidly. Also, at low altitudes it can constitute a large percentage of the altitude reading. Remedies for reducing or eliminating the step error in newer designs include:

- *Increases of the Swept Band* (since H_{step} is inversely proportional to swept bandwidth)—One hundred megacycles is believed to be an acceptable swept band for quantized sets. This value is being used on the STC 30-B1 for the low range.
- *Measurement of a Quantity That is a Continuous Function of Height Rather Than a Step Function*—According to AIL, an altimeter that is under development by Hasler Labs in Switzerland uses a drift-canceling heterodyne technique to measure the modulation index of the difference frequency. The FM-CW spectrum frequency modulates a very stable 200-kc IF. One of the outputs of the discriminator is an ac component varying at the modulating frequency. The amplitude of this component is proportional to height. Though the theory appears sound, Hasler is believed to have shelved the project.

Another way of reducing the step error uses an unquantized design, which eliminates the need for phase coherence between the heterodyned height signal and the sweep waveform. The trick lies in varying the phase of the RF signal at a rate exceeding that of the variation in altitude.

Figure 1 shows an unquantized design tried by STC. The heart of this system is a phase shifter that is varied by a small electric motor. The shift effectively removes the coherence between direct and reflected waves. Hence the group of counts in any frequency sweep is different from adjacent groups by an amount that depends on the phase shift of the direct wave during each sweep period. If the phase shift rate is fast with respect to the integrating time constant of the average rate counter, the latter will not show that the count is varying by a small amount at a relatively high rate, claims STC.

In Emerson's APN-100, another unquantized design, no clipping is used. Distance is derived by maintaining a constant modulation index of the difference frequency spectrum (ratio of frequency deviation to the frequency of the modulating wave). This index is measured at the mixer output and kept constant by a servo loop that adjusts the frequency deviation of the klystron transmitter tube. The shaft rotation of a servo-driven pot at null (constant index) is inversely proportional to altitude.

No step error occurs because a continuous quantity is being measured. The accuracy of the system depends on the sensitivity of the feedback loop and, as in all FM-CW designs, the stability of the transmitter modulation characteristics.

In the phase-CW comparison-type altimeter being developed by Laboratory for Electronics, the phases of the direct and reflected signals are compared. A 4000-mc carrier is amplitude-modulated (although either FM or AM could be used) by 10 mc for low ranges and 500 kc for higher range. The phases of the direct and reflected signal modulation envelopes are compared. The difference is a function of height.

Another unquantized design is being studied by the Army's Diamond Ordnance Fuze Labs. It uses noise to modulate the carrier. Distance is determined from the average relationship between outgoing and returned signals. DOFL labels its design an FM "anti-correlation" system and claims that it is no more complex than conventional altimeters.

To measure altitude the system counts zero crossings of the difference frequency signals. The rate of zero crossings is converted to a fluctuating voltage, squared, and averaged. The result is a measure of altitude.

An interesting feature of the system is that system characteristics can be changed easily by switching filters for the modulating noise. With simple filters, says DOFL, it is possible to build a system with its highest sensitivity at the shortest ranges. Breadboard version built at DOFL covers 5-5000 ft and is accurate to within four per cent.

DOFL has also experimented with a very-short-pulse (10-millimicrosec) radar altimeter. The set operates on X-band and has a pulse rep rate of "well over 100 kc".

Very short minimum ranges are gotten by means of an "off gate" applied to the IF amplified during transmission. Because of this gate, a decoupling ratio is set up between receiver and transmitter. This ratio determines the minimum range. At an 80-db ratio, the minimum range is slightly more than a foot.

One problem that might keep DOFL's design from being accepted is that, with ultrashort pulses, large signal bandwidths are required.

Measuring altitude with sound

Sonic altimeters don't appear to be the answer for low-altitude absolute measurement, but still they should not be overlooked. Their very short wavelength makes them attractive from the accuracy standpoint, and they can be designed in "micro-small" packages.

On the other hand, sonic altimeters are susceptible to extraneous noises and differences in reflection characteristics, have relatively short ranges, and the travel of sound waves is slow (compared with that of radio waves). This last drawback virtually rules out sonic altimeters for aircraft with high approach speeds.

Bendix Pacific has developed a pulsed sonic altimeter that weighs only 11.5 lb and, the company claims, is accurate to within six inches under 10 ft and within three per cent up to 300 ft. Arma has a lab model of a CW sonic type that, it believes, could be designed to weigh less than five pounds. This unit operates on 160 kc and uses quartz transducers with a conversion efficiency of 90 per cent.

Bendix Pacific has also developed a pulse radar altimeter operating at K_u-band with an 0.25-usec pulse. This unit is part of a 3-D radar that the company developed for Bell Helicopter under the ANIP program.

Part of the navigational radar energy is tapped off and radiated downward. The return is picked up by a separate antenna and receiver. The direct and reflected waves trigger separate oscillators each putting out a train of sine or square waves (on the order of a megacycle). A phase comparison circuit extracts a phase difference that is proportional to height.

Sharp time differences are gotten by preserving the leading edges of both tranmitted and received pulses. Altitude can be measured to within ½ ft at near-ground levels, claims Bendix. The weight of the altimeter components (receiver and antennas) is 5-6 lb.—End

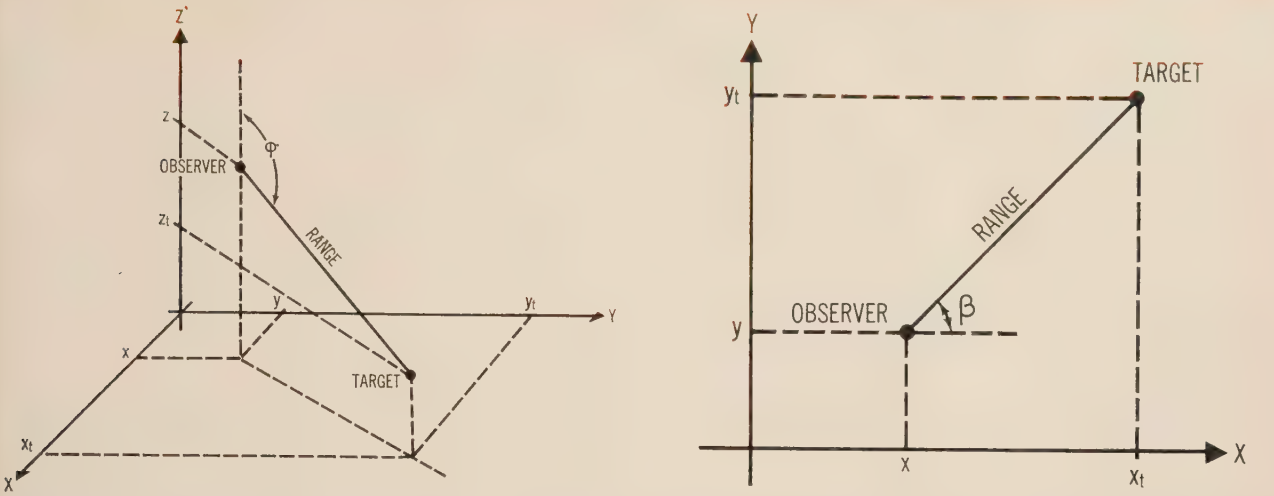

FIGURE 1: Reference system (left) used in acceleration ranging. The coordinates of the observer are X, Y, Z; those of the target, X_T, Y_T, Z_T. Right: two-dimensional plot of target-observer locations.

Acceleration ranging:

target distance from passive detector

Passive systems have been used with marked success in the search and track phases of air-to-air intercepts. A successful intercept, however, at some stage invariably requires a knowledge of target range. Here is a method of computing target range using only information from a passive tracker and own-vehicle motion sensors.

by C. V. R. Townsend and R. O. Sisson,
Engineers, Advanced Electronics Center, Light Military Electronics Dept., General Electric Co.*

PASSIVE DETECTORS, used to great advantage in modern airborne fire control systems, have no direct way of measuring range. One way of overcoming this drawback is to measure weapon-to-target angles (by passive means) while the weapon-carrying vehicle is accelerating. By using the information from the passive detector and from own-ship motion sensors, range can then be computed.

The frame of reference for "acceleration ranging" is the set of three orthogonal coordinates shown in *Figure 1*. The observer (own ship) is at point (X, Y, Z) and the target at point (X_T, Y_T, Z_T). The instantaneous derivatives of position are unspecified for either observer or target.

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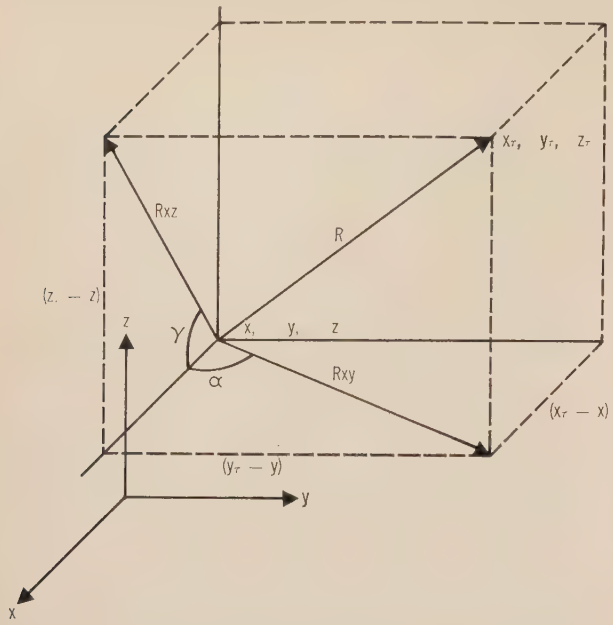

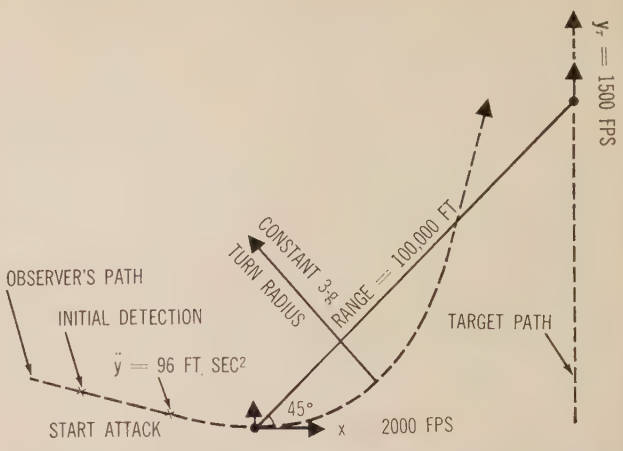

FIGURE 2: Coordinate system (left) for ranging by two-angle measurement. Above: Intercept geometry for first example.

For the sake of simplicity, however, let's first consider the case where the target and observer are positioned to move only in the XY-plane (*Fig. 1*). In effect we are projecting the three-dimensional action onto the XY-plane; the solution we get has to be multiplied by $1/\sin\theta$ to give the correct range.

Continuous tracking is assumed

As *Figure 1* shows, β is the angle between the X-axis and the line of sight from observer to target. We'll assume the observing vehicle continuously tracks the target and is instrumented to measure or compute its own positional derivatives as well as the target line-of-sight orientation and its derivatives. The number of quantities that must be measured depends on the number of unknowns for which values must be found, as we'll show by two examples:

- If the target is *stationary* with respect to the coordinate systems, the unknowns to be solved for are only X_T and Y_T, since all the derivatives of X_T and Y_T equal zero. To solve for these two unknowns, only two equations are needed. *Figure 2* shows that:

(1) $$\tan\beta = (Y_T - Y)/X_T - X).$$

Differentiation yields:

(2) $$\sec^2\beta\dot{\beta} = \frac{\dot{Y}_T - \dot{Y}}{X_T - X} - \left(\frac{Y_T - Y}{X_T - X}\right)\frac{\dot{X}_T - \dot{X}}{X_T - X}.$$

Equations 1 & 2 and the relationship:

(3) $$R = [(X_T - X)/\cos\beta]\,(1/\sin\theta)$$

combine to give:

(4) $$R = (\cos\beta/\dot{\beta})\,[(\dot{Y}_T - \dot{Y}) - \tan\beta\,(\dot{X}_T - \dot{X})]\,(1/\sin\theta).$$

Since the first derivatives of X_T and Y_T for a stationary target equal zero, *Equation 4* reduces to:

(5) $$R = \frac{1}{\beta}\left(\dot{X}\sin\beta - \dot{Y}\cos\beta\right)\left(\frac{1}{\sin\theta}\right).$$

Equation 5 shows that $\dot{X}$ and/or $\dot{Y}$ must have nonzero values if we are to get range information on a stationary target—i.e., the observer must be in motion. Also, if $\dot{\beta}$ equals zero, the range is indeterminate—no range information can be found for objects in the observer's direction of motion. Except for this special case, continuous range can be calculated once the values of the own-ship velocity components—$\dot{X}$, $\dot{Y}$, β, and $\dot{\beta}$—are measured.

- If the target is *moving* at a constant velocity in a straight line, the unknowns are X_t, Y_t, $\dot{X}_t$, and $\dot{Y}_t$, while $\ddot{X}_t$, $\ddot{Y}_t$, and higher derivatives equal zero. Since two new unknowns have been added, two additional equations are needed to solve for range. The third equation is found by differentiating *Equation 3:*

(6) $$\sec^2\beta\left(2\dot{\beta}^2\tan\beta + \ddot{\beta}\right) =$$

$$\frac{\ddot{Y}_T - \ddot{Y}}{X_T - X} - \left(\frac{Y_T - Y}{X_T - X}\right)\left(\frac{\ddot{X}_T - \ddot{X}}{X_T - X}\right)$$

$$- 2\left[\frac{\dot{Y}_T - \dot{Y}}{X_T - X} - \left(\frac{Y_T - Y_P}{X_T - X}\right)\left(\frac{\dot{X}_T - \dot{X}}{X_T - X}\right)\right]\left(\frac{\dot{X}_T - \dot{X}}{X_T - X}\right).$$

Equation for constant speed target

Equation 2 can be combined with *Equation 6;* since the target is not accelerating, *Equation 6* can be reduced to:

(7) $$\sec^2\beta\left(\dot{\beta}^2\tan\beta + \ddot{\beta}\right) = \frac{\ddot{X}}{X_T - X}\tan\beta$$

$$- \frac{\ddot{Y}}{X_T - X} - 2\sec^2\beta\dot{\beta}\frac{\dot{X}_T - \dot{X}}{X_T - X}$$

The fourth equation results from differentiation of *Equation 7:*

(8) $$\sec^2\beta\left(2\dot\beta^3\sec^2\beta+4\dot\beta^3\tan^2\beta+6\ddot\beta\dot\beta\tan\beta+\dddot\beta\right)=$$

$$\frac{\dddot X}{X_T-X}\tan\beta-\frac{\dddot Y}{X_T-X}$$

$$-\frac{\dot X_T-\dot X}{X_T-X}\left(\frac{\ddot X}{X_T-X}\tan\beta-\frac{\ddot Y}{X_T-X}-2\dot\beta\sec^2\beta\frac{\dot X_T-\dot X}{X_T-X}\right)$$

$$+\frac{\ddot X}{X_T-X}\left(3\dot\beta\sec^2\beta\right)-2\sec^2\beta\frac{\dot X_T-\dot X}{X_T-X}\left(\ddot\beta+2\dot\beta^2\tan\beta\right)$$

By simplifying *Equation 8* and using *Equation 3*, we get the final equation for range:

(9) $$R=\{\dddot X\sin\beta-\dddot Y\cos\beta+\ddot X\,[3\dot\beta\cos\beta-3/2\,(\ddot\beta/\dot\beta)\sin\beta]+Y\,[3\dot\beta\sin\beta+3/2\,(\ddot\beta/\dot\beta)\cos\beta]\}/\{\sin\theta[\,2\dot\beta^3-3/2(\ddot\beta^2/\dot\beta)+\beta\,]\}.$$

The equation shows that, for the case of the target moving at a constant velocity, we must measure $\ddot X$, $\ddot Y$, $\dddot X$, $\dddot Y$, β, $\dot\beta$, $\ddot\beta$, and $\dddot\beta$. Interestingly enough, $\dot X$ and $\dot Y$ are not needed. However, since own-ship acceleration and its derivatives appear, the observer has to accelerate to get range. During acceleration, range data are continuously available.

Instrumentation can be simpler

Equation 9 gives range when the observer's motion is unrestricted and nothing is known about the target except that it is moving in a straight line and at a constant velocity. If the observer's motion can be specified, the instrumentation can be simplified. Likewise the range equations can be simplified considerably if the observer knows something about the target. Let's examine these two possibilities:

- Assume the observer accelerates in such a manner that $\ddot X$ and $\ddot Y$ are zero. This case requires constant X- and Y-acceleration and velocity components linearly dependent on time. Generally:

(10) $$\ddot X=K_x,\ \ddot Y=K_y,$$

(11) $$\dot X=K_x t+C_x,\ \dot Y=K_y t+C_y.$$

The velocity (v) and acceleration (a) of the observer are:

(12) $$v=[(K_x^2+K_y^2)\,t^2+2(C_xK_x+C_yK_y)\,t+(C_x^2+C_y^2)]^{1/2},$$

(13) $$a=[K_x^2+K_y^2\,]^{1/2}.$$

Equation 9, giving range, then can be simplified to:

(14) $$R=\{[\dddot X(3\dot\beta\cos\beta-3/2(\dot\beta/\ddot\beta)\sin\beta)+\ddot Y\,(3\dot\beta\sin\beta+3/2(\ddot\beta/\dot\beta)\cos\beta)]/[2\dot\beta^3-3/2(\ddot\beta^2/\dot\beta)+\dddot\beta]\}\ (1/\sin\theta).$$

If acceleration is limited to the X-direction:

(15) $$v=K_x t+C_x,\ a=K_x,$$

$$R=\frac{\dddot X\,[3\dot\beta\cos\beta-3/2(\ddot\beta/\dot\beta)\sin\beta]}{2\dot\beta^3-3/2(\ddot\beta^2/\dot\beta)+\dddot\beta}\left(\frac{1}{\sin\theta}\right)$$

Another restriction of the observer's motion would be to require him to fly in such a manner that $\dot\beta$ equals zero. From *Equation 2*, we get:

(16) $$\dot\beta=\cos^2\beta\left(\frac{\dot Y_T-\dot Y}{X_T-X}-\frac{\dot X_T-\dot X}{X_T-X}\tan\beta\right).$$

Since $\dot\beta$ equals zero, we get:

(17) $$\tan\beta=(\dot Y_T-\dot Y)/(\dot X_T-\dot X).$$

To fulfill this requirement, the vector representing closing velocity must lie along the line of sight from observer to target. The range equation now reduces to:

(18) $$R=[(\ddot X\sin\beta-\ddot Y\cos\beta)/\dddot\beta]\ (1/\sin\theta).$$

The solution of this equation requires less instrumentation and computing effort than the earlier range equations. However, when *Equation 16* is satisfied, $\ddot\beta$ cannot equal zero, or R becomes indeterminate. If R is found from *Equation 18*, it can be determined only intermittently at those discrete times when $\ddot\beta$ passes through a value of zero. R clearly is indeterminate when the observer is continuously on a collision course.

- Now let's assume we have additional information about the target—for example, we know its velocity. The observer now can find the range of the target without accelerating; he merely has to fly a straight course. The four equations used to solve for range are *Equations 1 & 2* and:

(19) $$\sec^2\beta\,(2\dot\beta^2\tan\beta+\ddot\beta)=-2\frac{\dot X_T-\dot X}{X_T-X}\left[\frac{\dot Y_T-\dot Y}{X_T-X}-\left(\frac{Y_T-Y}{X_T-X}\right)\frac{X_T-\dot X}{X_T-X}\right],$$

(20) $$v_T^2=\dot X_T^2+\dot Y_T^2.$$

Equation 19 is *Equation 6* rewritten to reflect the fact that now $\ddot X$, $\ddot Y$, $\ddot X_T$, and $\ddot Y_T$ equal zero. *Equation 20* states the new assumption that the target's velocity (v_T) is known. The range expression resulting from the simultaneous solution of these equations is:

(21) $$R=\{[\dot X\,(2\dot\beta^2\sin\beta+\ddot\beta\cos\beta)-\dot Y\,(2\dot\beta^2\cos\beta-\ddot\beta\sin\beta)]/[2\dot\beta^3+(\ddot\beta^2/2\dot\beta)]+\sqrt{[\dot X(2\dot\beta^2\sin\beta+\ddot\beta\cos\beta)-\dot Y(2\dot\beta^2\cos\beta-\ddot\beta\sin\beta)]^2-(4\dot\beta^4+\ddot\beta^2)(v^2-v_T^2)}/[2\dot\beta^3+(\ddot\beta^2/2\dot\beta\,]\}(1/\sin\theta).$$

$\ddot X$, $\ddot Y$, $\dddot X$, $\dddot Y$, $\dddot\beta$ no longer needed

The parameters needed to determine range when target velocity is known are $\dot X$, $\dot Y$, β, $\dot\beta$, and $\ddot\beta$. When we compare *Equations 9 & 21*, we see that $\ddot X$, $\ddot Y$, $\dddot X$, $\dddot Y$, $\dddot\beta$ are no longer needed. This should save a good deal of instrumentation and computation. *Equation 21* also shows that, if the observer is on a lead collision course or on a parallel course at the same speed as the target, $\dot\beta$ equals zero and R becomes indeterminate.

Equation 21 can be simplified by orienting the X-axis along the observer's line of flight. Now the range formula becomes:

(22) $$R=\{\dot X\,(2\dot\beta^2\sin\beta+\ddot\beta\cos\beta)/[2\dot\beta^3+(\ddot\beta^2/2\dot\beta)]+\sqrt{X^2\,(2\dot\beta^2\sin\beta+\ddot\beta\cos\beta)^2-(4\dot\beta^4+\ddot\beta^2)(v^2-v_T^2)}/[2\dot\beta^3+(\ddot\beta^2/2\dot\beta)]\}(1/\sin\theta).$$

Another piece of information that may be available to the observer is the target's course. Let the angle be defined by:

(23) $$\dot Y_T/X_T=\tan\psi,$$

and assume it is known. Also assume that *Equations 1, 21, 19, & 23* apply and that $\ddot X$, $\ddot Y$, $\ddot Y_T$, and $\ddot Y_T$ equal zero. This leads to:

(24) $$R=\{2\dot\beta(\dot X-\dot Y\cot\psi)/[2\dot\beta^2(\cot\psi\cos\beta+\sin\beta)+\ddot\beta(\cos\beta-\cot\psi\sin\beta)]\}(1/\sin\theta).$$

Again, since the target's course is known, the observer does not have to accelerate to get range.

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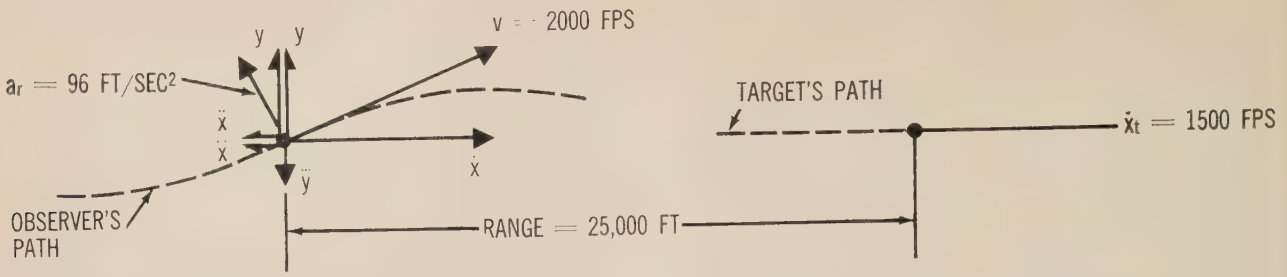

FIGURE 3: Intercept geometry for second example.

So far we have discussed the determination of target range from an accelerating observation point when the derivatives of only *one* angle to the line of sight are known. In this case, third and all lower derivatives of own-ship motion and line-of-sight angle must generally be found for computing the range to a target with uniform velocity. But if you have a system that can measure derivatives of *two* independent angles to the line of sight, only the second and lower derivatives of own-ship motion and line-of-sight orientation are required.

Figure 2 shows the coordinate system and nomenclature for passive ranging by measuring two angles to the line of sight. R_{xy} and R_{xz} are, respectively, the projections of R on the XY- and YZ-planes of the orthogonal, inertial XYZ-coordinate system; α and γ are the angles between the X-axis and R_{xy} and R_{xz}, respectively.

From *Figure 3*, we get:

$$\tan\alpha = (Y_T - Y)/(X_T - X), \tag{25}$$

$$\tan\gamma = (Z_T - Z)/(X_T - X). \tag{26}$$

Differentiation of both these equations gives:

$$\sec^2\alpha\,\dot{\alpha} = \frac{\dot{Y}_T - \dot{Y}}{X_T - X} - \left(\frac{Y_T - Y}{X_T - X}\right)\frac{\dot{X}_T - \dot{X}}{X_T - X}, \tag{27}$$

$$\sec^2\gamma\,\dot{\gamma} = \frac{\dot{Z}_T - \dot{Z}}{X_T - X} - \left(\frac{Z_T - Z}{X_T - X}\right)\frac{\dot{X}_T - \dot{X}}{X_T - X}. \tag{28}$$

A second differentiation gives:

$$\sec^2\alpha\left(2\dot{\alpha}^2\tan\alpha + \ddot{\alpha}\right) = \frac{\ddot{Y}_T - \ddot{Y}}{X_T - X} - \left(\frac{Y_T - Y}{X_T - X}\right)\left(\frac{\ddot{X}_T - \ddot{X}}{X_T - X}\right) - 2\left(\frac{\dot{X}_T - \dot{X}}{X_T - X}\right)\left[\frac{\dot{Y}_T - \dot{Y}}{X_T - X} - \left(\frac{Y_T - Y}{X_T - X}\right)\frac{\dot{X}_T - \dot{X}}{X_T - X}\right], \tag{29}$$

$$\sec^2\gamma\left(2\dot{\gamma}^2\tan\gamma + \ddot{\gamma}\right) = \frac{\ddot{Z}_T - \ddot{Z}}{X_T - X} - \left(\frac{Z_T - Z}{X_T - X}\right)\left(\frac{\ddot{X}_T - \ddot{X}}{X_T - X}\right) - 2\left(\frac{\dot{X}_T - \dot{X}}{X_T - X}\right)\left[\frac{\dot{Z}_T - \dot{Z}}{X_T - X} - \left(\frac{Z_T - Z}{X_T - X}\right)\left(\frac{\dot{X}_T - \dot{X}}{X_T - X}\right)\right]. \tag{30}$$

Equations 25-30 are enough to solve for the six unknowns X_T, Y_T, Z_T, $\dot{X}_T$, $\dot{Y}_T$, and $\dot{Z}_T$. Higher derivatives are assumed to equal zero.

Solving for X_T-X yields:

$$X_T - X = \frac{\left(\frac{\ddot{Y} - \ddot{X}\tan\alpha}{\sec^2\alpha\,\dot{\alpha}}\right) - \left(\frac{\ddot{Z} - \ddot{X}\tan\gamma}{\sec^2\gamma\,\dot{\gamma}}\right)}{\left[2\dot{\gamma}\tan\gamma + (\ddot{\gamma}/\dot{\gamma})\right] - \left[2\dot{\alpha}\tan\alpha + (\ddot{\alpha}/\dot{\alpha})\right]}. \tag{31}$$

All the terms on the right side of *Equation 31* can be measured by the observer. Range is given by:

$$R = \sqrt{(X_T - X)^2 + (Y_T - Y)^2 + (Z_T - Z)^2}, \tag{32}$$

which can be written:

$$R = (X_T - X)\sqrt{1 + \tan^2\alpha + \tan^2\gamma} = (X_T - X)\sqrt{\sec^2\alpha + \tan^2\gamma}. \tag{33}$$

So finally we get:

$$R = \{\sec^2\gamma\,\dot{\gamma}\,(\ddot{Y} - \ddot{X}\tan\alpha) - \sec^2\alpha\,\dot{\alpha}\,(\ddot{Z} - \ddot{X}\tan\gamma)\}/\sec^2\alpha\sec^2\gamma\left[\dot{\alpha}\,(2\dot{\gamma}^2\tan\gamma + \ddot{\gamma}) - \dot{\gamma}\,(2\dot{\alpha}^2\tan\alpha + \ddot{\alpha})\right]\sqrt{\sec^2\alpha + \tan^2\gamma}. \tag{34}$$

If you want to use *Equation 34* to generate continuous range data, the observer must be accelerating in such a manner that first and/or higher derivatives of both α and γ exist—$\dot{\alpha}$ and $\ddot{\alpha}$ cannot simultaneously be zero, nor can $\dot{\gamma}$ and $\ddot{\gamma}$, or R becomes indeterminate.

Simplification limits maneuvers

In general, $\dot{\alpha}$, $\ddot{\alpha}$, $\dot{\gamma}$, $\ddot{\gamma}$, $\ddot{X}$, $\ddot{Y}$, and $\ddot{Z}$ must be measured to calculate range from *Equation 16*. As we have seen, you can eliminate some of the terms in the range equation by maneuvering so that some of the variables go to zero. The price of such simplification is that the observer can no longer freely choose the interception path and cannot get continuous range data while maneuvering.

To evaluate the difficulties of instrumenting the acceleration ranging technique, we have specified several tactical situations and computed the values of the variables that would be measured by the observer. We'll describe three such situations here, for all of which we'll assume that observer's velocity (v_o) is 2000 fps = Mach 2; observer's radial acceleration (a_o), 96 ft/sec² = 3 g; target's velocity (v_T), 1500 fps = Mach 1.5:

- The observer meets his target at roughly beam aspect and makes a g-limited turn to bring him onto a collision course following the target (*Fig. 2*). Variables are computed for the instant at which β equals 45 deg, the range is 100,000 ft, and the observer is executing a 3-g radial acceleration turn.

If *Equation 9* is used to find range, the following variables would be measured: $\beta = 45$ deg, $\dot{\beta} = 24.8 \times 10^{-3}$ rad/sec = 1.46 deg/sec, $\ddot{\beta} = 0.5\times10^{-3}$ rad/sec² = −0.029 deg/sec², $\dddot{\beta} = 0.018\times10^{-3}$ rad/sec³ = −0.001 deg/sec³, $\ddot{X} = 0$, $\ddot{Y} = 96$ ft/sec², $\dddot{X} = -4.60$ ft/sec³, $\dddot{Y} = 0$.

• The observer is behind the target and needs range information to complete his attack (by launching a missile, for example). To get range, he accelerates by zig-zagging with a 3-g lateral acceleration while positioned directly behind the target at a range of 25,000 ft (*Fig. 3*).

Two seconds after starting the turn, the values of the necessary variables are computed as: $\beta = 0$, $\dot{\beta} = -7.8\text{x}10^{-3}$ rad/sec $= -0.45$ deg/sec, $\ddot{\beta} = -4.1\text{x}10^{-3}$ rad/sec^2 $= -0.24$ deg/sec^2, $\dddot{\beta} = 0.23\text{x}10^{-3}$ rad/sec^3 $= 0.014$ deg/sec^3, $\ddot{X} = -9.2$ ft/sec^2, $\ddot{Y} = 95.5$ ft/sec^2, $\dddot{X} = -4.59$ ft/sec^3, $\dddot{Y} = -0.44$ ft/sec^3. With these values, range can be found accurately from *Equation 9*.

It's interesting that, from the above values and *Equation 18*, range can be calculated as 23,200 ft. This is only seven per cent off from 25,000 ft—despite the fact that $\dot{\beta}$ is not zero, as was assumed in deriving *Equation 18*. When $\dot{\beta}$ is very small, it appears *Equation 18* may serve for estimating range to the accuracy required in most cases.

• The observer makes a diving turn toward the target and is instrumented to measure two angles and compute range from *Equation 34* (*Fig. 4*). This is essentially a three-dimensional version of our first example. The observer starts 10,000 ft above the target at a slant range of 100,000 ft and makes a circular descending turn, pulling 3 g of lateral acceleration. At the instant of observation: $\dot{X} = 0$, $\dot{Y} = 1970$ fps, $\dot{Z} = -347$ fps, $\ddot{X} = 83$ ft/sec^2, $\ddot{Y} = 0$, $\ddot{Z} = -48$ ft/sec^2, $\alpha = 45$ deg, $\dot{\alpha} = -24.6\text{x}10^{-3}$ rad/sec $= -1.41$ deg/sec, $\ddot{\alpha} = 0.43\text{x}10^{-3}$ rad/sec^2 $= 0.025$ deg/sec^2, $\gamma = -8$ deg 5 min, $\dot{\gamma} = 7.8\text{x}10^{-3}$ rad/sec $= 0.446$ deg/sec, $\ddot{\gamma} = 0.198\text{x}10^{-3}$ rad/sec^2 $= 0.011$ deg/sec^2.

The general condition of the acceleration ranging technique is that the observer be able to measure—on his line of sight to the target—as many quantities as there are unknowns in target position and motion that influence the measurements.

For the case of a target moving at constant velocity in a straight line, two somewhat different methods for finding range have been suggested:

• The derivatives of only one angle between the line of sight to the target and the reference axes are measured. In our analysis this angle θ lies in the XY-plane, so only position derivatives in that plane influence the measurements. The unknowns in this case are X_T, Y_T, Z_T, $\dot{X}_T$ and $\dot{Y}_T$, and five quantities must be measured on the line of sight to find range: β, $\dot{\beta}$, $\ddot{\beta}$, $\dddot{\beta}$, and θ.

• With two independent angles to the line of sight instrumented, an additional variable, $\dot{Z}_T$, influences the measurements. Therefore six instead of five measurements on the line of sight must be made: α, $\dot{\alpha}$, $\ddot{\alpha}$, γ, $\dot{\gamma}$, and $\ddot{\gamma}$. The observer must also measure some of his own ship's linear motions.

Observer's motions are restricted

Unfortunately, in acceleration ranging the observer not only must measure enough variables, but the values of the variables also must not continuously equal zero, or the range equation becomes indeterminate. This requirement limits the motion of the observer while he makes his measurements.

If he has no information on his target other than that it is traveling in a straight line, the observer must accelerate to get the data for the range computation. If he is instrumented to measure only one angle to the line of sight to the target, he must have an acceleration component in the plane of that angle. If he is instrumented to measure two independent angles to the line of sight, he must have acceleration components in the planes of both angles.

Some intercept paths involve continuous acceleration of the observer and some only transient acceleration at the start and near the end of the intercept. The choice of approaches therefore seems wide enough to let the observer select one that will give the necessary range data whenever acceleration ranging is used.

Range equation can be modified

If the approach that would yield the desired range information is ruled out by important operational requirements, then it may be possible to modify the range calculations and get range by somewhat devious means. For example, a collision course is an excellent approach for many purposes, but is not at all suited to acceleration ranging. However, during the initial maneuvering to get the observer on a collision course, range can be computed. Once the target range is known, target course and velocity are readily computed. And once he knows the target's course and velocity, the observer can get range from target bearing and own-ship motion information while he is on a collision course.

Naturally, acceleration ranging has some major limitations. As our numerical examples show, the angular derivatives that must be measured are very small. Error analysis may reveal that, for acceptable range errors, the tolerances on the angular rate measurements will strain or exceed the present state of the art in instrumentation. In addition, there will certainly be some major problems in building a passive tracker that can follow a target at useful ranges to the accuracy required for the range calculations.

Finally, our analysis has been limited to non-accelerating targets. This suggests that a target could foil an acceleration-ranging observer quite simply by maneuvering. However, it is hard to see right off just how the target could take advantage of this possibility, nor is it obvious that what the target might gain in degrading the observer's range data is worth the penalty it would have to pay.—End

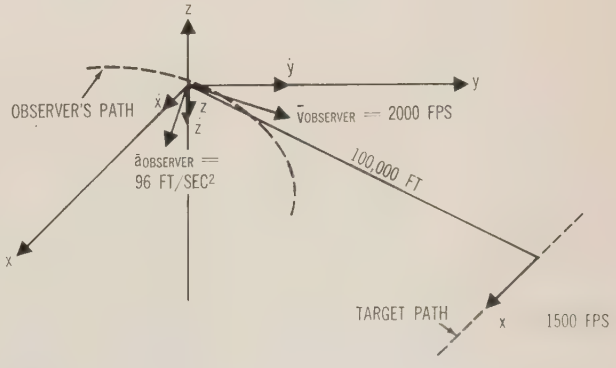

FIGURE 4: Intercept geometry for third example.

RCA

MESA

COMPUTER TRANSISTORS

2N1300 · 2N1301

feature

HIGH POWER DISSIPATION
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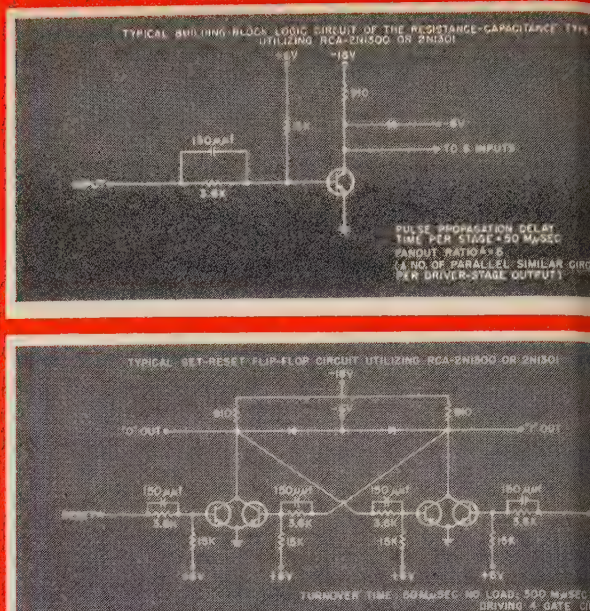
AT LOW COST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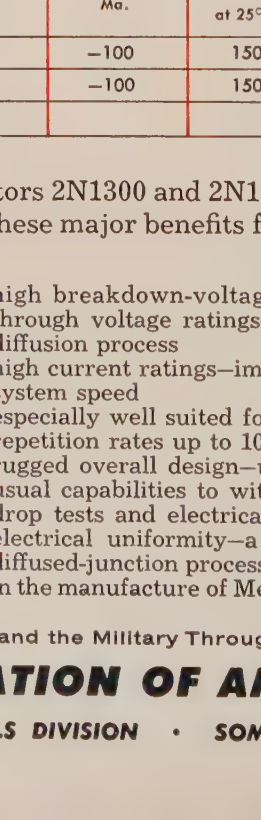
PULSE PROPAGATION DELAY TIME PER STAGE = 50 MμSEC
FANOUT RATIO = 6
(6 NO. OF PARALLEL SIMILAR CIRCUITS PER DRIVER-STAGE OUTPUT)
TYPICAL SET-RESET FLIP-FLOP CIRCUIT UTILIZING RCA-2N1300 OR 2N1301
TURNOVER TIME = 50 MμSEC NO LOAD; 500 MμSEC DRIVING 4 GATE
TYPICAL "NOT-AND" GATE CIRCUIT UTILIZING RCA-2N1300 OR 2N1301
INPUT LEVEL
INPUT PULSE
PULSE DELAY TIME = 20



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	Collector-to-Base Volts	Collector-to-Emitter Volts	Emitter-to-Base Volts	Collector Ma.	Transistor Dissipation Milliwatts			Minimum DC Current Transfer Ratio		Gain-Bandwi Produc Mc
					at 25°C	at 55°C	at 71°C	at collector ma = −10	at collector ma = −40	
2N1300	−13	−12	−1	−100	150	75	35	30	–	40
2N1301	−13	−12	−4	−100	150	75	35	30	40	60
▲For collector ma = −10 and collector-to-emitter volts = −3										

RCA's Germanium P-N-P Mesa Transistors 2N1300 and 2N1301 combine low-cost and quantity availability with these major benefits for designers of switching circuits:

- high power dissipation—150 milliwatts maximum at 25°C, 75 milliwatts maximum at 55°C
- fast switching times—made possible by high frequency response and low total stored charge
- rugged Mesa structure—with an extremely small base width to insure top performance at high frequencies
- high current transfer ratio—permits high fanout ratios (number of paralleled similar circuits per driver-stage output)
- high breakdown-voltage and punch-through voltage ratings—result of the diffusion process
- high current ratings—improves overall system speed
- especially well suited for use at pulse repetition rates up to 10 Mc
- rugged overall design—units have unusual capabilities to withstand severe drop tests and electrical overloads
- electrical uniformity—a result of the diffused-junction process used by RCA in the manufacture of Mesa Transistors

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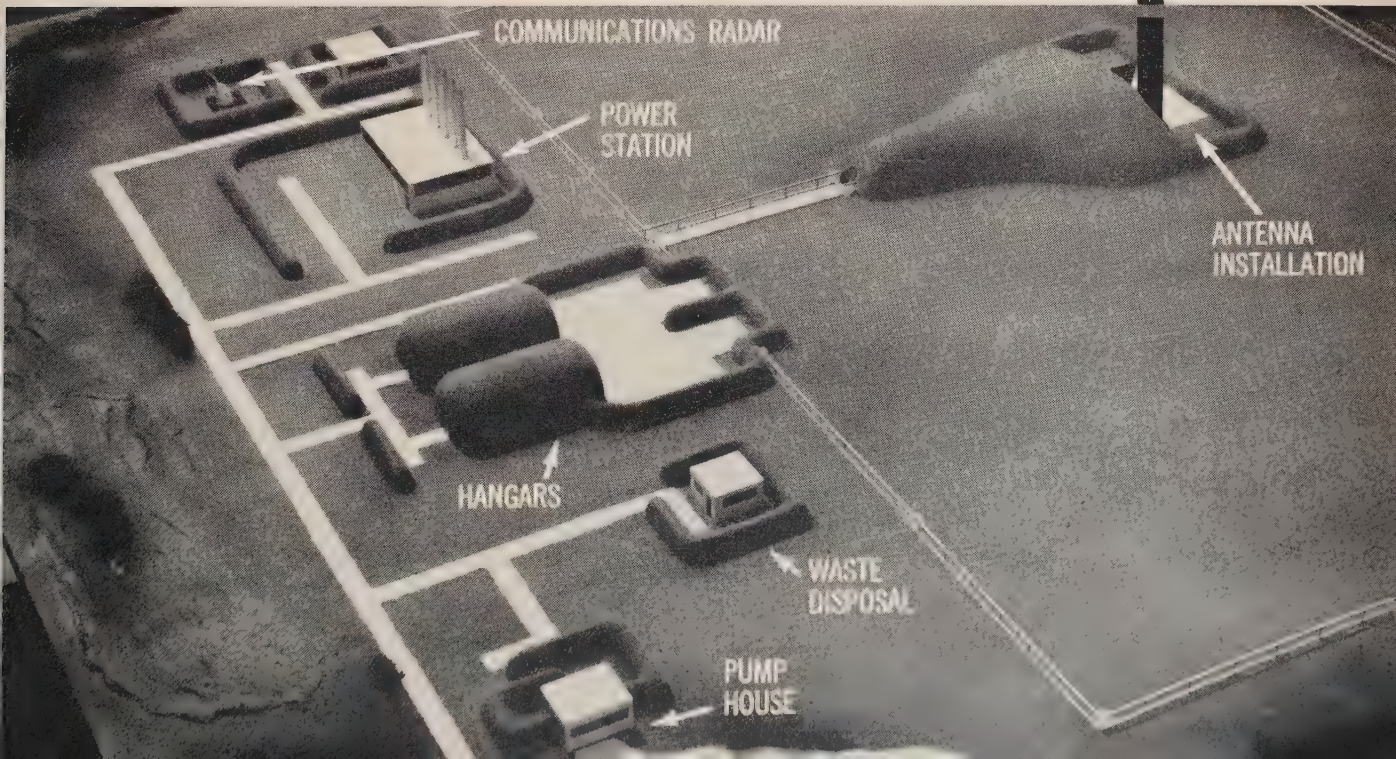
design digest

Powering recon platforms

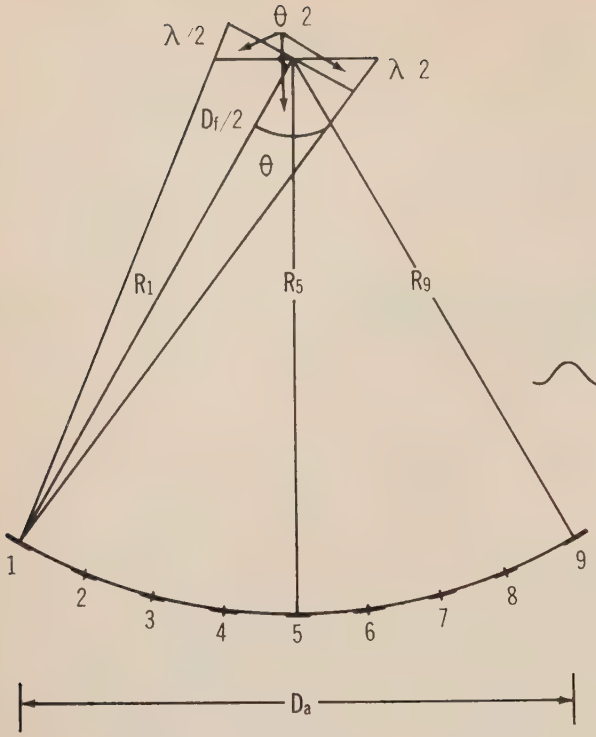
with microwaves

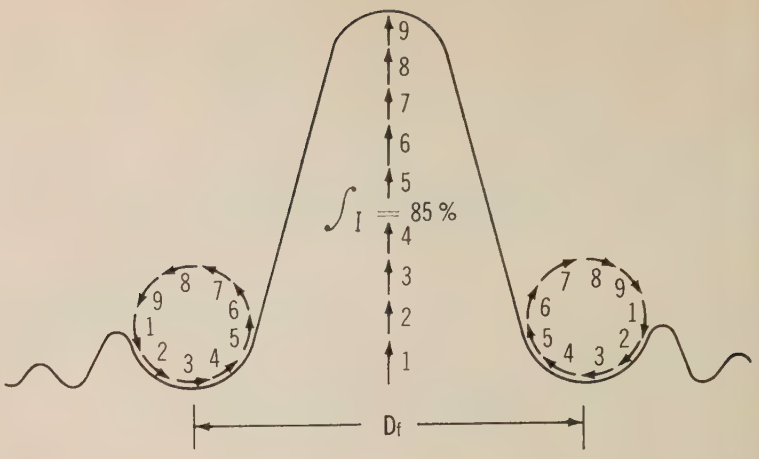
THE development of a more efficient, high power version of its "amplitron" microwave amplifier tubes, Raytheon Co., Waltham, Mass., points out, lends added weight to its proposal for keeping unmanned rotary-wing platforms on station in the stratosphere by sustained HF microwave transmission. Raytheon figures about 12,000 kw of RF power would be needed, assuming only about six per cent overall efficiency (RF-to-rotor power). The ground base would include a complete steam-generator plant, communications, and hangars for the vehicles. A 400-ft array of transmitting antennas, fed by a dozen ganged amplitrons, would focus the microwaves on a 50-ft-diameter receiving antenna in the bottom of the vehicle, hovering directly overhead at 65,000 ft. The vehicle antennas would connect to the resistive-load portion of a heat exchanger built into a gas turbine powering the rotors. The idea of cable-less power transmission has long intrigued engineers. The services (USAF in particular) are interested in its potential for missile and aircraft detection, navigation, and communications. Write in No. 54 on Reader Service Card for more information.

by Bernard Kovit, Associate Electronics Editor



GROUND STATION is fairly complex, using a steam powerplant feeding a bank of amplitrons to generate power. Copters ascend to hover point by chemical power.



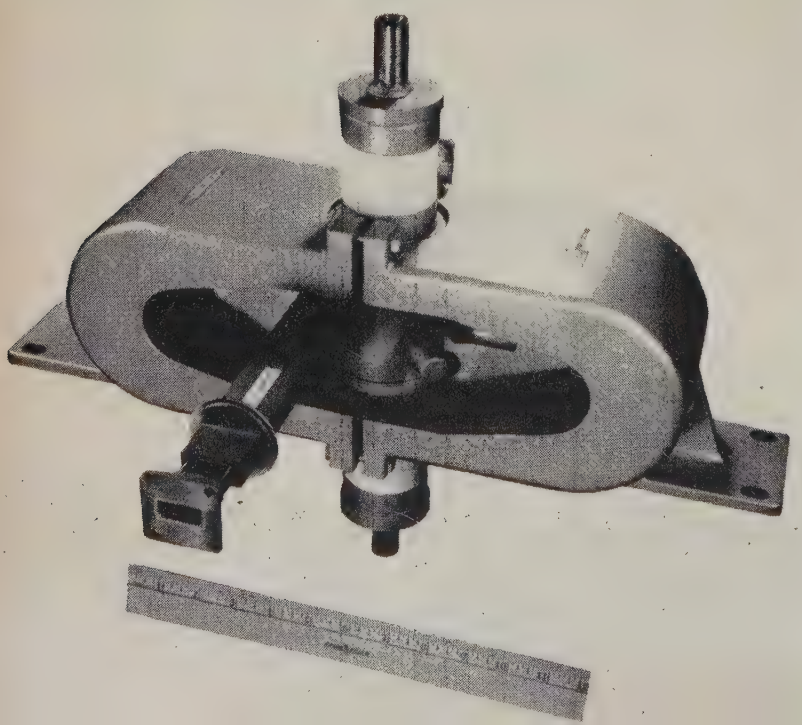


$$\frac{\lambda/2}{D_f/2} = \frac{D_a/2}{R}$$

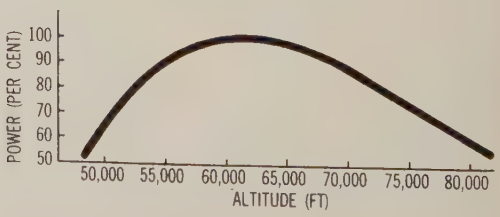
$$D_f = \frac{2R\lambda}{D_a}$$

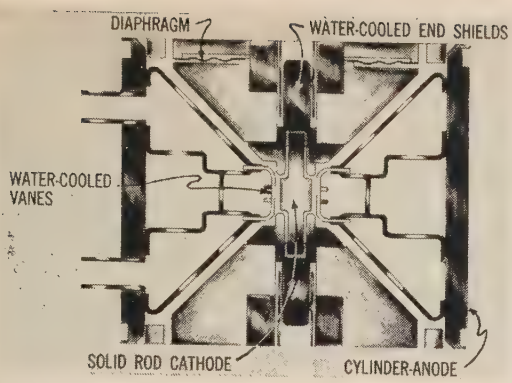
ASSUMING: $D_a = 400$ FT
$\lambda = 1/3$ FT (S-BAND)
$R = 50{,}000$ FT
THEN: $D_f = 85$ FT

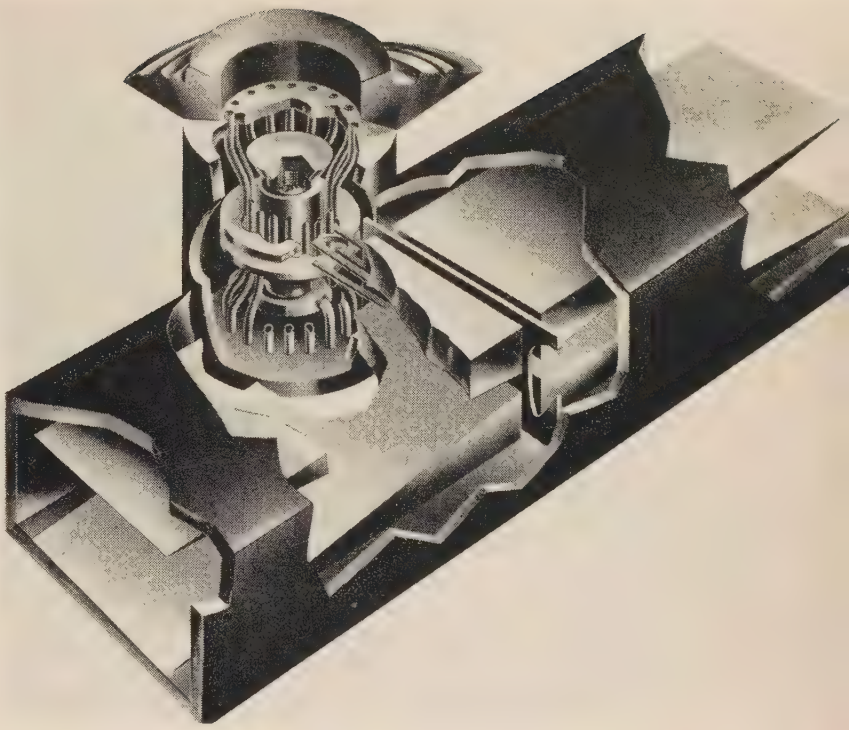
EFFICIENT POWER TRANSMISSION requires that the energy be focused at the hover plane—in contrast to the usual radar practice of focusing the antenna on infinity. Raytheon's method (above) calls for producing a spherical wave front all of whose parts arrive at the focus point in phase. You could use an ellipsoid antenna made up of a phased linear array of horns separately connected to amplitrons, suitably phased, and using a common driver. The beams arrive at either side of the focal point in systematically varying phase; at first null, the energy adds up to zero for complete cancellation, and so on. Ideally, 85 per cent of the transmitted energy ($\int_I$) could pass through the regions bounded by the first nulls. Raytheon figures that about 75 per cent of this energy could be captured with an antenna whose diameter is two-thirds that of the focal spot (defined by the first nulls). The formula lets you figure the size of the focal spot (D_f) and so the size of the airborne antenna, where D_a is the diameter of the ground antenna and λ the wavelength. A 55-ft antenna in the hovering vehicle could capture the transmitted energy with an efficiency of about 64 per cent. Raytheon believes that atmospheric breakdown probably will not pose a problem—at 10 cm, the atmosphere at up to 200,000 ft has supported powers on the order of 1000 hp/m² before the onset of breakdown. The present application could not conceivably involve horsepowers of over 100 per square meter.



KEY COMPONENT for powering Raytheon's sky platform is the amplitron. Reportedly it handles 10 times as much power as any existing S-band device with 80 per cent efficiency. Small X-band model (left) was built to prove the dissipation of high anode temperatures of super-power operation. Even this model has handled 8 kw. Raytheon says it can build tubes giving over 200 kw average power. Below: Computer analysis curve of relative power at altitude for a point-fed and focused antenna. Distance between feed and focus is 64,000 ft; antenna diameters are 340 and 50 ft on ground and aloft, respectively; wavelength is five cm.



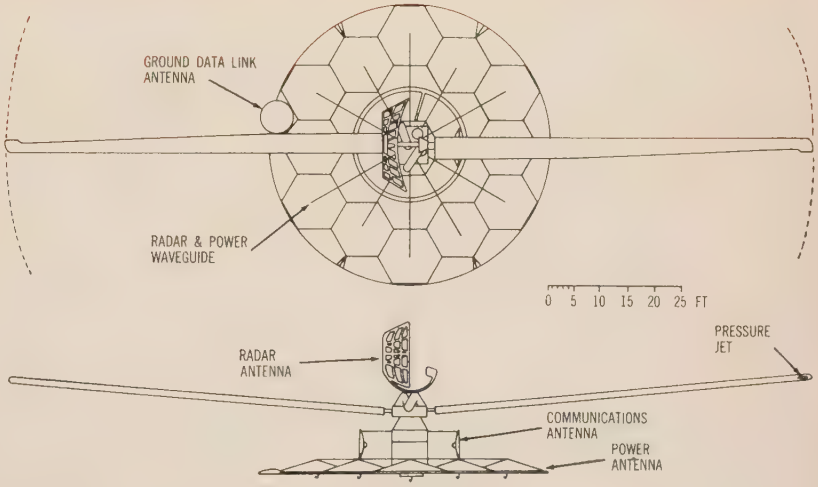




IMPROVED COOLING technique that was developed to multiply tenfold the amplitron's power handling ability uses water injection. Slow-wave structure is of 0.018-in.-ID tubing through which water flows. Heat generated by electron bombardment against the structure is carried through 0.006-in.-thick tube wall to coolant. Future designs may handle well over 3-5 kw/cm². Right: Cross-section of X-band CW tube showing how cathode is supported between two water-cooled pole pieces.

System Efficiencies

Primary power to microwave power	0.50
Transmission beam	0.85
Atmospheric transfer efficiency	0.95
Intercept percentage	0.75
Capture antenna efficiency	0.70
Heat exchanger efficiency	0.98
Engine efficiency	0.30
Over-all efficiency	0.059
Required over-all power	2000/0.059 ≅32,000 hp
Required over-all RF power	32,000/2 ≅16,000 hp =12,000 kw

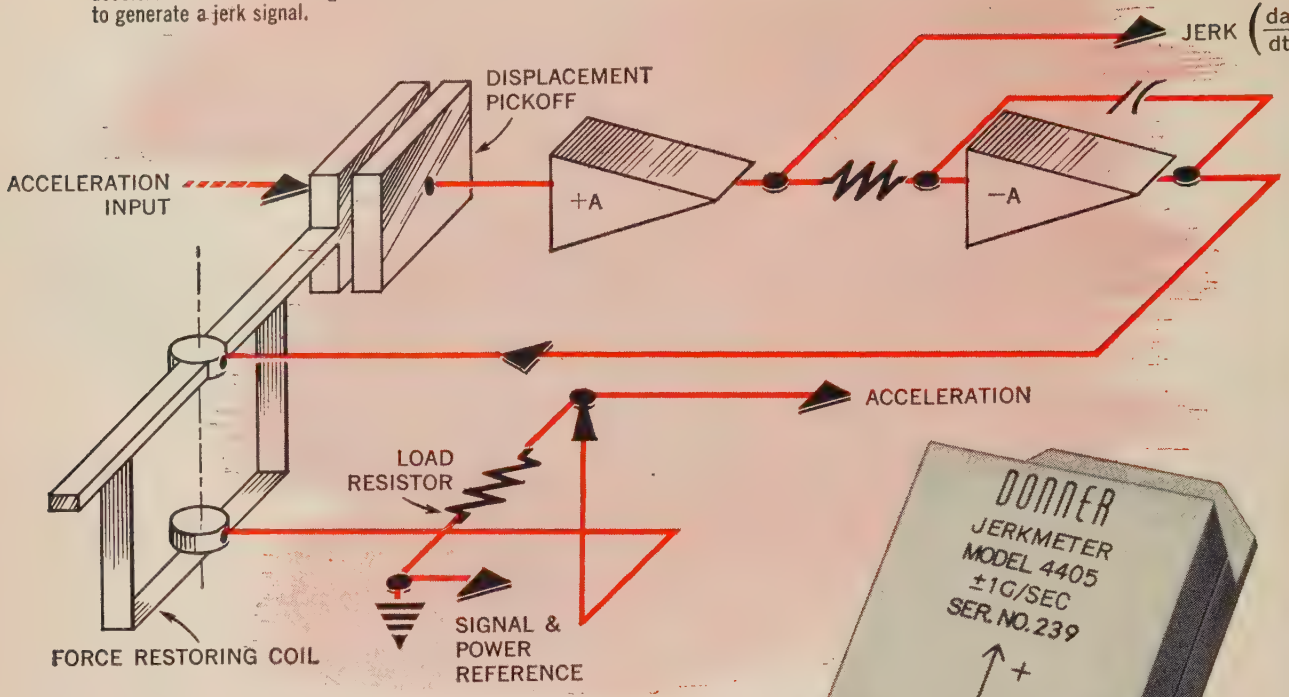


Helicopter Parameters

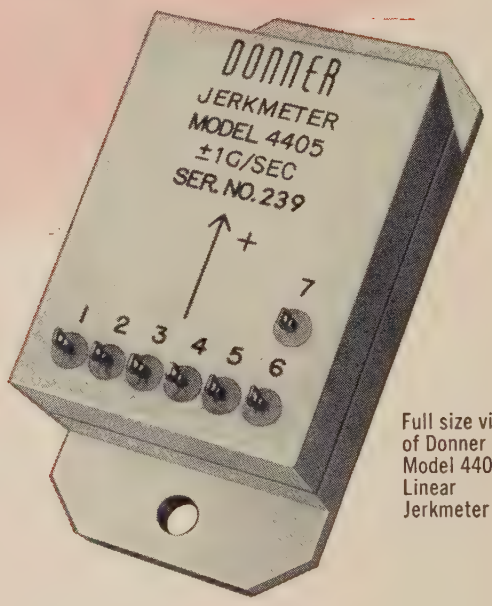
Collector antenna weight	3000 lb
Rotor and hub weight	3500 lb
Power plant weight (at one lb/hp)	2000 hp
Structure	1200 lb
Empty weight	9700 lb
Payload	2000 lb
Supplementary chemical fuel	600 lb
Take-off weight	12,300 lb
Rotor blades	2
Rotor diameter	160 ft
Average rotor chord	8 ft
Rotor tip speed	700 fps
Required rotor power	1550 hp
Required auxiliary power	155 hp
Required shaft power (65,000 ft)	2000 hp

HELICOPTER VEHICLE—A 50-ft-diameter receiving antenna carried in the helicopter's bottom would be made up of a number of smaller antennas, each independently connected to a resistive load. This arrangement makes the entire array less directive, so that changes in copter attitude cannot cause power losses. One or more of these individual antennas might connect directly to a radar antenna carried topside. The resistive load would be part of a heat exchanger forming the combustion chamber of the engine. Shaft power is used to pump air out through the tip jets. From stability studies, Raytheon concludes that the vehicle will keep position on top of the beam to within a few feet in any gust condition occurring at altitude. Trim tab control would handle altitude stabilization. The polarization of the microwave power forms a reference for heading stabilization. Since the vehicle would have very low disk loading, it could descend fairly simply by autorotating, using short bursts of power for maneuvering. It would ascend by using stored chemical power. One of the interesting implications for navigation is that a radar antenna in the vehicle and another on the ground stand at two ends of a precise vertical baseline. This feature obviously could be exploited for height-finding, for example.

Functional diagram of Donner Linear Jerkmeter. This unique instrument operates as a subminiature servo-system of the force-balance type which is responsive to jerk along the sensitivity axis of the linear unit and about the sensitive axis of the angular unit. Basically, the system consists of a transistorized accelerometer with an integrator inserted into the servo-loop to generate a jerk signal.



HOW TO MEASURE $\frac{da}{dt}$



Full size view of Donner Model 4405 Linear Jerkmeter

New Donner precision Jerkmeters measure linear and angular jerk to ±0.5% or better.

If your measurement and control problem requires accurate measurement of jerk or the rate of change of acceleration, Donner Scientific's new line of precision angular and linear jerkmeters can help.

These new instruments are the only truly accurate device of this type ever made. They are designed to meet the most demanding applications. Both angular and linear jerkmeters provide an output voltage proportional to jerk which in turn can be used to instigate compensatory control forces or other actions. *An acceleration analog output voltage is also available.*

Typically, a jerkmeter installed in a jet aircraft will provide an instantaneous output proportional to the rate of change of g's. This signal can be used to predict impending disaster conditions.

Other applications include use wherever constant acceleration is required. Here, the Donner jerkmeter provides a "velocity-damping" term. The jerkmeter also provides a third order term for stabilizing displacement devices. It can also be used as an inertial indicator of first motion.

KEY SPECIFICATIONS for Model 4405 Linear Jerkmeter

RANGES
Acceleration: ±1 g full range to ±30 g full range
Jerk: ±0.5 g/sec full range to ±20 g/sec full range

OUTPUT FULL SCALE
Accelerometer: ±7.5 v dc
Jerk: ±7.5 v dc

RESOLUTION
0.1% full scale or better

LINEARITY
0.1% full scale or better

HYSTERESIS
Less than 0.1%

POWER
+15 v dc at 10 ma and −15v dc at 10 ma

SIZE
3" long, 1½" wide, 1⅝" high

WEIGHT
7.5 ounces

WANT MORE INFORMATION? *The new Donner Jerkmeter is another product from a firm specializing in the manufacture of accurate fixed and general purpose analog systems designed to analyze, measure, and control inputs interlocking time, acceleration, jerk, velocity, and other dynamic inputs. Complete technical information can be obtained by calling your nearby Donner engineering sales representative or writing Dept. 092*

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Figuring frequency from CRO patterns

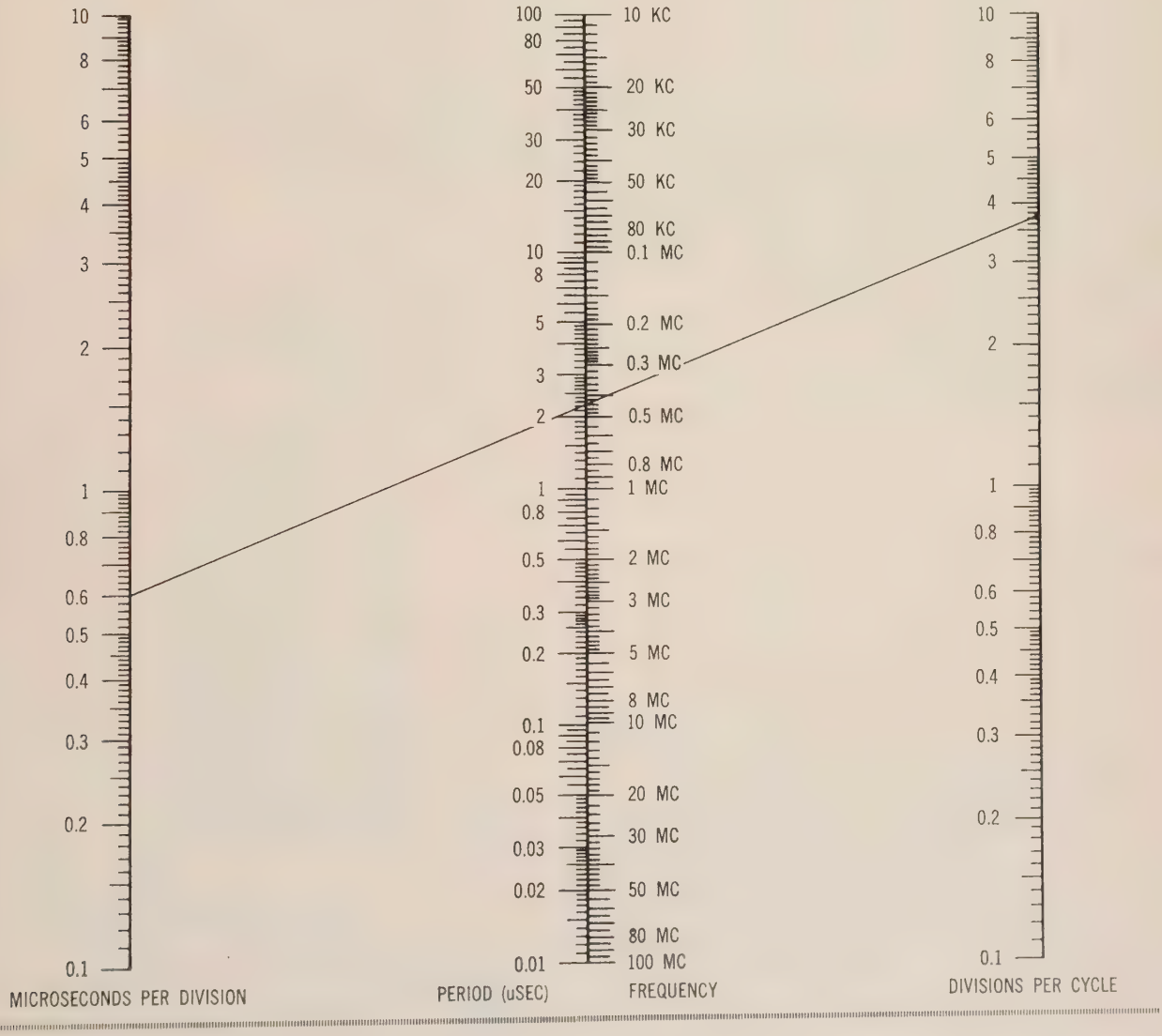
by **Donald Moffat,**
Senior Electronics Designer, Motorola, Inc.*

KNOWING sweep speed, you can calculate the frequency of a pattern on an oscilloscope—if you have a slide rule handy. Actually, you don't even need the slide rule. In our lab, we have eliminated all calculation with the help of a nomograph.

The nomograph is simple to use. For example, let's assume that the sweep speed is set at 0.6 usec/cm and that one period of the display covers 3¾ cm. Find these points on the nomograph and draw a straight line between them. This line intersects the frequency scale at 0.44 mc, the display frequency. The intersected scale also shows that the period is 2.25 usec.

To extend the range of the scales, you need only multiply the frequency scale by any power of 10 and the microseconds-per-division and period scales by the reciprocal of the same power of 10.—End

* Motorola, Inc., Western Military Electronics Center, 8201 McDowell Rd., Phoenix, Ariz.



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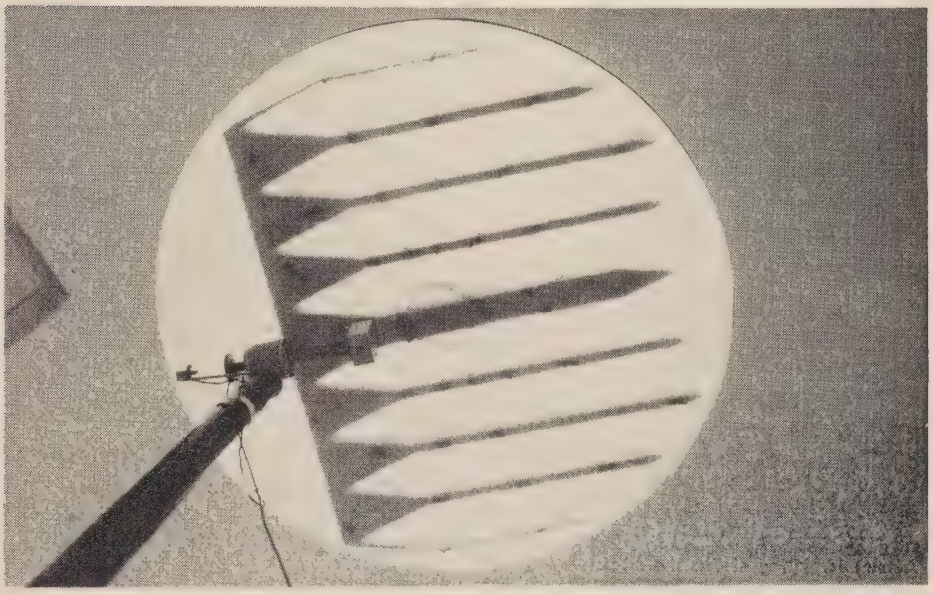
RSW antenna

mates UHF radar to AEW planes



RSW ANTENNA in its radome. This type of antenna has several advantages for airborne UHF radar and has been studied for use in early-warning aircraft.

Antennas for UHF radars must be large. In ground installations, large antenna structures can be handled with "brute-force" techniques—but in airborne applications, they can't. In mounting UHF antennas on early-warning aircraft, for instance, the designer often is forced to compromise UHF propagation as he mates his array to the plane.

by E. H. Flath and E. G. Keiffer,
Antenna Engineers, Chance Vought Aircraft, Inc.*

BECAUSE of their size, UHF radar antennas are quite difficult to install in early-warning aircraft. You usually are forced to make a tradeoff between aerodynamic (drag and weight) performance and radar performance. In an effort to find the best compromise between conflicting performance demands, designers have made a thorough study of end-fire arrays.

This type of antenna has a number of advantages for airborne UHF (300-500-mc) radar, principally that it allows a smaller aperture height—

(1) Electronics Div., Chance Vought, Inc., Dallas 22, Texas. The authors invented the antenna described in this article together with J. D. Clanton, who was killed last year by a lightning bolt while working on the antenna on the roof of Chance Vought's antenna lab.

more on next page

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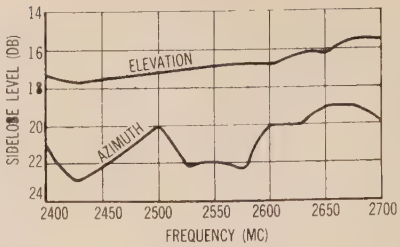

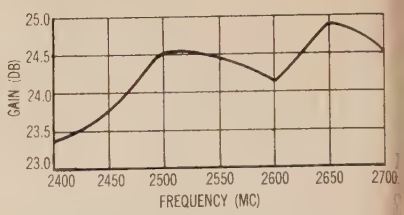

FIGURE 1: Sidelobe level and on-axis gain of a 1/6-scale model of a retarded-surface-wave antenna.

in the end-fire array, length can be traded for height. For the airplane, a smaller vertical dimension means better aerodynamic performance and (because of reduced antenna weight) lower overall weight.

Beamwidths on the order of those usually required for airborne early warning (AEW) can be gotten readily with arrays short enough to fit in a normal-sized radome. A properly designed end-fire array also makes a rotodome[2] practical, with the antenna supplying the structural strength. Another advantage of the end-fire design is that with it you can locate the effective center of radiation farther away from reflecting objects (like an airplane fuselage) to lessen pattern deterioration. As for antenna gains and sidelobes, the same orders of magnitude can be obtained with end-fires as with more conventional antennas.

Probably the commonest types of element used in end-fire designs are the yagi dipole, disk, and open-horn arrays. The first two basically are limited by the form of the antenna, which cannot be adapted to supporting a radome.

CV's work on open-horn type began in 1954

In 1954, Chance Vought (CV) began working on an open-horn antenna based on a combination of broadside and end-fire arrays. The broadside array controlled the pattern in azimuth, and the end-fire array controlled it in elevation.

One of the big problems with this design was beamwidth. The general rule of thumb for the half-power beamwidth of an end-fire array shows a beamwidth of 26 deg is about optimum for a 5.1-wavelength-long array. We made a comprehensive study, using the retarding principle, to find an optimum surface for a 5-10-wavelength-long array. Typical configurations had round and square holes and dielectric and loaded dielectric surfaces. None of these surfaces met the half-power-beamwidth criteria.

However, beamwidth was not the only factor. Broad-banding, power handling, structural quality, fabricability, and requirements of a rotodome also had to be taken into account.

All these considerations point to an array of non-resonant elements. In terms of fabricability, the simplest design of this kind is a slot. An analysis of non-resonant slots shows that the half-power beamwidth criteria can be met. In fact, the phase velocity can be controlled by controlling the length of the slots (*Fig. 2*). This concept underlies the design of the retarding surfaces for the CV antenna.

In company-sponsored programs, CV has built some 12 antennas that would range from 17.5 to 45 ft in diameter in full scale. To date, our work has been confined to 1/6- and 1/12-scale models. Tests on such models have been run at Wright Aeronautical Development Center and the Naval Research Lab.

Our early work was done on a 1/12-scale model of a 23-ft-diameter antenna. This design has eight bays, each with a 5.1-wavelength-long retarding surface. The azimuthal pattern is six degrees at the half-power points; the elevation pattern is 23 deg. Measured on-axis gain is 22.7 db with a sidelobe level of 18 db.

The overall height of a full-scale model would be about 18 in. Since existing radomes are designed for conventional antennas, the additional height available in the radome makes possible a stacked array of retarded surface antennas. Such stacking would allow four-lobe monopulse operation.

A series of tests was run by CV

more on page 154

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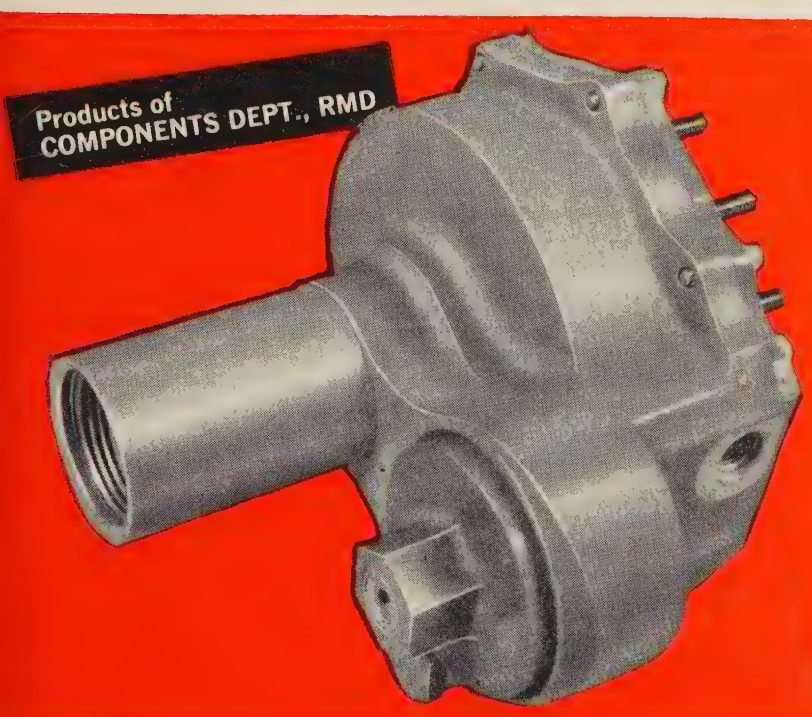

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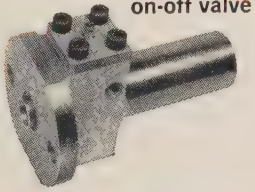

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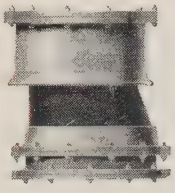

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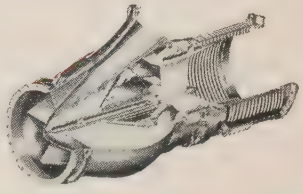

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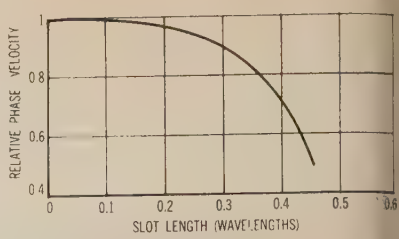

FIGURE 2: The design of Chance Vought's retarded-surface-wave antenna is based on the fact that phase velocity is a function of slot length.

on stacked antennas. The peak gain for two 23-ft-diameter antennas was 25 db. Beamwidths for this combination were six degrees in azimuth and 11.5 deg in elevation. Measurements of sidelobe level, on-axis gain, and elevation beamwidth all showed the retarded-surface-wave antenna to conform to the general rules of antenna design. With a five-foot spacing, a performance is obtained that is the equivalent of a 10.5-ft parabola capable of monopulse operation in elevation and azimuth.

To test scaling effects and to move on to a frequency at which corporate-feed structures could be built, we made a 1/6-scale model of an eight-bay, 35-ft-diameter antenna. This antenna operated as predicted at 2550 mc. The azimuth pattern was 4.3 deg with a 20 db sidelobe level; the elevation pattern was 20.7 deg with a 10 db sidelobe level.

We concluded that there are no scale problems, that monopulse operation is possible in both azimuth and elevation, and that the rotodome principle can be made to work. Structural calculations showed that, with the antenna acting as a structure, one-inch-thick honeycomb would suffice for the radome itself.

To get an idea what a retarded-surface-wave antenna can do for an AEW system, we first had to study the effect of the airframe. A series of patterns were run for various installation locations on airframes—above- and below-fuselage locations and some "exotic" ones. In all cases our studies showed that generally better patterns are achievable with the retarded-surface-wave antenna than with a standard parabola.

To check the effect of the radome on antenna operations, we built a

more on page 156

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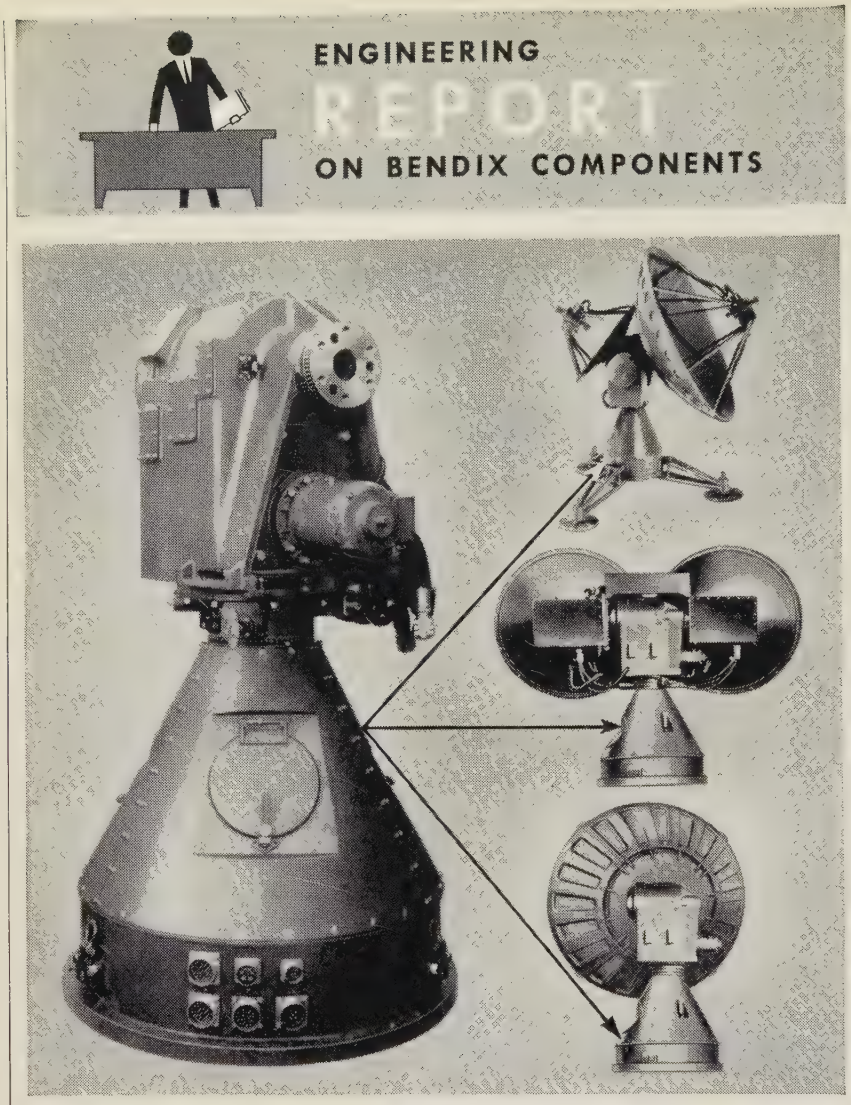

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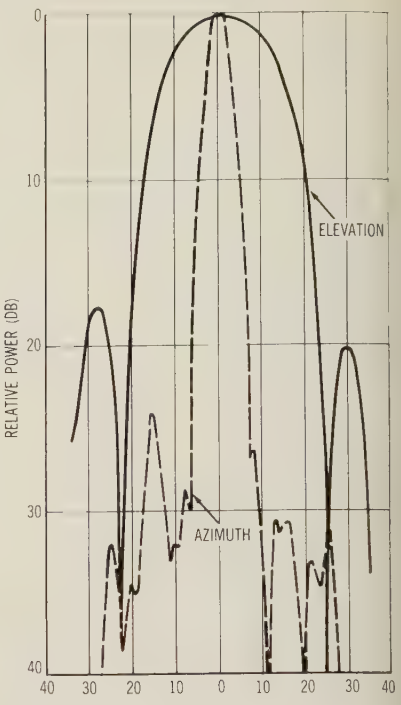
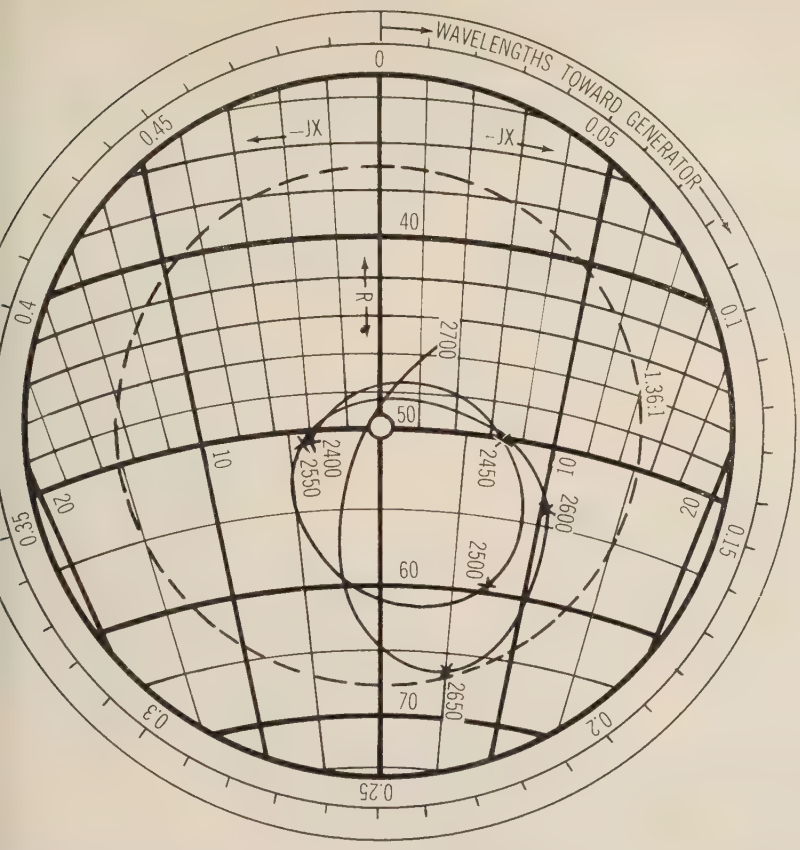


FIGURE 3: Typical azimuth and elevation plane patterns obtained with refined versions of the retarded-wave-surface antenna in horizontal polarization and with cross-polarization below 25 db.

1/6-scale model of an antenna measuring 35 ft full scale. This antenna was designed so that we would be able to study the radome shell independently of the supporting fiberglass structure. We found that the best design both structurally and electronically was a spoke-beam arrangement. Patterns run on the antenna with the radome shell alone show the azimuthal pattern to be reduced from 4.3 to 4.2 deg and the elevation pattern from 20.7 to 16.2 deg. Since elevation beamwidth changed, some mechanism had to be set up as a basis of measurement. Antenna gain, therefore, was calculated from these beamwidths with a weighting factor based on prior history. Subtraction of the calculated figure from the measured gain gave an estimated loss of 0.76 db from the radome shell alone.

When the spoke structure was inserted, the beamwidths remained essentially unchanged. The measured on-axis gain of this combination was 24.9 db. By a series of calculations similar to the one we had run through before, we found the losses for this combination to be 0.9 db.

A complete series of patterns was run across the frequency range



GURE 4: Smith chart plot of impedance at the input to the corporate-ed structure. No effort was made to center the impedance curve on the art.

the ⅛ scale model. Each of the ys was fed by a corporate-feed ucture. The elevation sidelobe el varies from 14 to 18 db over 2700-2400-mc range. Azimuth elobe level over the same fre-ency range varies from 18 to 22 On-axis gain varied from 23.5 24.5 db (*Fig. 1*).

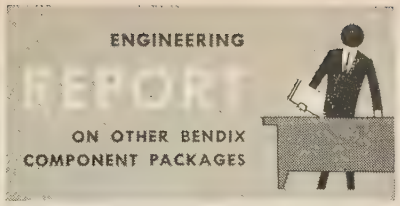
These gain measurements in-ded an average increase of 0.6 due to the radome. This in-ase, naturally, has to be taken o account in the antenna design. The corporate-feed structure, erating at S-band, contributed a db loss. This loss, however, uldn't occur at the operating fre-ency of the search radar. When these effects are considered, one ibel can be added to the an-na-rotodome combination gain operation at the full-scale fre-ency.

The impedance working into the porate-feed structure across the quency range had a maximum 6, as shown in the polar plot *Figure 4*. You can see that no rt was made to center the curve the Smith chart. Actually, a bet-VSWR can be gotten by adjust-the impedance curve with suit-able transformers. The VSWR would be even better for the full-scale model, since variations in the individual feed structures would be minimized.

Some of the important conclusions we reached as a result of our test and development program are:

- Since non-resonant slots can be used in the end-fire array, this design must have adequate power handling capability.
- This type of retarding surface makes it possible to place an I-beam structure along the lines of the antenna.
- A weight reduction of about two or three to one can be achieved.
- The effect of the radome on electric operations can be determined and presents no problems.
- The antenna is simple to build and will be quite cheap in production quantities.

Development of the basic retarding-wave design is continuing. Design refinements and further analysis of feed distributions are already yielding patterns with sidelobe levels down 24-25 db with little, if any, loss in on-axis gain (*Fig. 3*).—End



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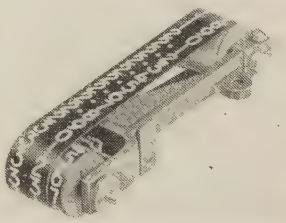

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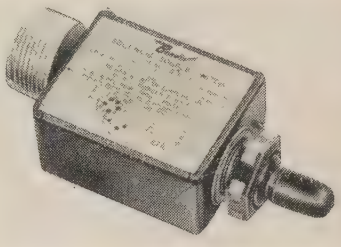

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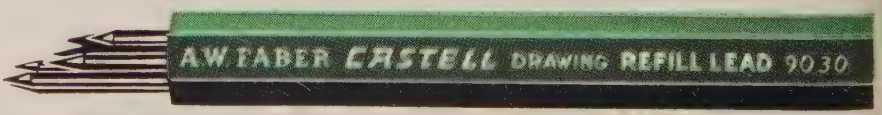

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"HELIONICS" is one of the latest entries in the lexicon of electronic jargon. Apparently dreamed up by engineers at Thompson Ramo Wooldridge's Tapco Group, it stands for the conversion of solar heat to electric energy.

RELIABILITY can be enhanced by a simplified system of communications between the design engineer and the mathematician who has to work out failure probability. This claim was made in an interesting paper, "A New Method of Communication Between Engineer and Mathematician Aids System Reliability Prediction," given by C. Weldon Holtzman, Jr., and William E. Marshall, of Minneapolis-Honeywell's Ordnance Division, at Hopkins, Mo., at last month's National Symposium on Reliability and Quality Control in Electronics.

In essence, here's how this communications setup works: The engineer draws a block diagram of his system and in each block states in short sentences or phrases how component successes or failures must combine to make the system work. The advantage of this technique is that the engineer needs only a superficial knowledge of mathematical prediction methods.

AT ONE TIME in the remote past, "airline electronics" meant radio navcom gear, and that was that. Now the non-radio equipment comes close to outweighing the radios. In a modern airliner, the other-than-radio electronic equipment may include: autopilots, flight directors, fuel gages, fire detectors, compass systems, flight data recorders, navigation computers, air data systems, prop controls, engine ignition analyzers, engine vibration analyzers, electronic regulators, and controls for the plane's electric system.

CONVAIR ASTRONAUTICS estimates that about 70 per cent of every dollar it spends for procurement on the Atlas ICBM goes for electronics. Fifty per cent of the airborne electronics and some 65 per cent of the ground checkout electronics is made by Astronautics, it is claimed.

COUNTER-COUNTERMEASURE against air defense radar jamming is the frequency diversity radar net being set up at strategic locations throughout the U.S. USAF is spending some $160 million on the program, which involves the following radars: FPS-24 (GE), FPS-26 (Avco-Crosley), FPS-27 (Westinghouse), FPS-28 (Raytheon), and FPS-35 (Sperry).

NUCLEAR propulsion systems have given the submarine speed and depth capabilities that make it one of the most formidable weapons of modern warfare. This is well known. Less well known is that the nuclear reactor-turbine designs used in modern subs are very noisy, making the sub an excellent sonar target. Reportedly the noise rises steeply with increasing turbine rpm. Commanders can run quietly at reduced speeds, but this nullifies the speed advantage of the nuclear boat. The Navy is working hard on methods of quieting nuclear engines.

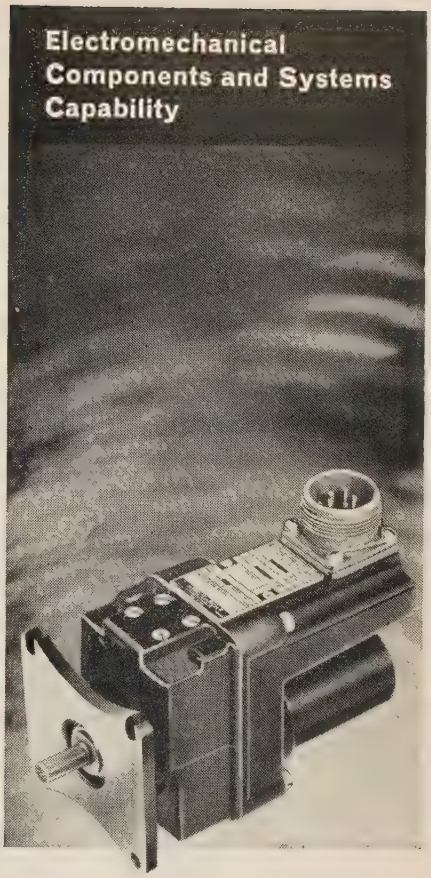
NOVEL DETECTOR for spotting undersea objects is in the preliminary test stage at Mediowave Corp., New Brunswick, N. J. The device (which can be used for undersea communications, too), is called "Mediowave". It has a range of 20-30 miles, according to its inventor Vernon Bugg, who is also president of Mediowave.

Bugg expects to propose his device to the Office of Naval Research. He told SPACE/AERONAUTICS that test results to date have been variable—one day his detector works fine, the next day not at all.

THE OPERATING principle of the Mediowave device is company-proprietary, but Bugg did reveal that it is not a propagation technique. It is believed that water is used as a conductive path, which could mean the use of very low frequency currents.

Piasecki Aircraft has the manufacturing rights to the device.

PROJECT MERCURY'S communications system will use 11 transmitters and six receivers. The astropilot in the Mercury capsule will have both a push-to-talk switch and a voice-operated relay (VOX), according to McDonnell Aircraft, prime contractor on the project. To keep noise from the rocket boosters from turning on the transmitter, the VOX will not be operable until the boosters have separated, says McDonnell.



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Electronic and Mechanical Designers—engineers with background in transistor circuitry, inertial sensor development and evaluation, and precision mechanical equipment design are needed to perform component development and evaluation, and to design mounting and alignment equipment.

APPLIED RESEARCH

Programmer Analyst—mathematician with experience in the use of medium and large scale digital computers for analysis of scientific problems.

Human Factors Engineer—capable of analysis and direction of experiments in human motor skills, and application to man-machine systems involving automatic control techniques.

Systems Analyst—capable of conducting research studies involving new techniques of space navigation and guidance.

DESIGN AND DEVELOPMENT

Flight Control Systems—analytical, systems, and component engineers to work in areas such as advanced flight reference and guidance systems. Positions range from analyzing stability and control problems, systems engineering—through design, testing, and proof of electrical and mechanical equipment—including flight test and production test.

Advanced Gyro Design—Engineers with two and up to twenty years' experience in precision gyro and accelerometer development, servo techniques, digital techniques, solid state electronic development, advanced instrumentation and magnetic component design.

Electronic Circuit Designers—experienced in the areas of analog/digital computers, transistor circuits, servos, instrumentation, and/or gyro stabilization.

For the less experienced professional engineer, there are opportunities in the Evaluation Laboratory which lead to careers in any of the above fields.

To investigate any of the above professional opportunities at the Aeronautical Division, please write in confidence to Bruce Wood, Dept. 368

To explore professional opportunities in other Honeywell operations coast to coast, send your application to H. K. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

Honeywell

AERONAUTICAL DIVISION

1433 Stinson Blvd. NE, Minneapolis 13, Minnesota

Check Employment Inquiry Form on Page 161

space/aeronautics

CONFIDENTIAL

February 1960
(good until 4/15/60)

Employment Inquiry Form

(Not an application for employment)

THIS INQUIRY FORM is a service that makes it easier for the interested reader to explore employment opportunities with organizations featuring recruitments advertising **in this issue.**

To use this Form, follow these simple steps:

(1) Tear out this page.

(2) Check off the organization(s) listed below whose employment offers are of interest to you. **Use typewriter or pencil.**

(3) Turn to the back page of this Form and answer the questions on it.

(4) Mail this form (in a stamped envelope) to:

Reader-Service Dept.
SPACE/AERONAUTICS
205 East 42nd St.
New York 17, N.Y.

We will do the rest and promptly forward a copy of your Inquiry Form to each of the organizations you have checked. Depending on their specific personnel requirements, they will get in touch with you at your home.

I am interested in the employment opportunities at:

☐ Aeronutronic Div. of Ford Motor Co.	169	RCA	
☐ AiResearch Mfg. Co.	202, 214	☐ Advanced Military Syst. Dept.	164
☐ Bendix-Pacific Div.	170	☐ Air Systems Dept.	171
☐ Convair; Astronautics Engrg. Div.	85, 86, 87, 88	☐ Govt. Service	168
☐ Garrett Corp.	202, 214	☐ Raytheon Mfg. Co.	163
General Electric Co.		☐ Republic Aviation Corp.	170
☐ Heavy Military Elect. Dept.	253	☐ Rocketdyne; A Div. of North American Aviation, Inc.	164
☐ Light Military Elect. Dept.	169	☐ Rohr Aircraft Corp.	166
☐ Guided Missiles Range Div.; PanAm Airways, Inc.	281	☐ Ryan Aeronautical	124
☐ Lockheed Aircraft Corp.	62, 63, 277	☐ Space Technology Labs.	27
☐ Martin Co., The; Denver Div.	106	☐ Systems Development Corp.	167
☐ Minneapolis-Honeywell Regulator Co. Aero Div.	160	☐ Vitro Weapons Services	166
☐ Pan American Airways, Inc.; Guided Missiles Range Div.	281	☐ Westinghouse Electric Corp.	165

OTHER (Some organizations' recruitment advertising in this issue may have arrived too late for inclusion in the above list. If you are interested in the employment offers of any of these organizations, just note its name and the page number of its advertisement in this space. Please refer only to ads keyed to this form.): _____

_____

_____

NOTE: If you have an immediate interest in any special employment opportunity advertised in this issue and would like to give more details about your qualifications than can be noted on this Form, we advise you to send your resume directly to the person or department given in the advertisement. We'd appreciate it if you'd mention SPACE/AERONAUTICS in your application.

space/aeronautics

CONFIDENTIAL

February 1960
(good until 4/15/60)

Employment Inquiry Form

Please type or print (with pencil)

(NOT an application for employment)

FIELDS OF INTEREST (in order of importance, note the general fields in which you would like to work—e.g., basic research, dynamics, structures, rocket propulsion, electronic systems, pneumatics, testing, materials, production, ground support, etc.): _____

SPECIALIZED JOB EXPERIENCE (describe the specific technical areas in which you have worked —e.g., flutter, fatigue, fuel systems, circuit miniaturization, servo systems, hydraulic pumps, tool engineering, orbit mechanics, telemetry, data processing, wind tunnel testing, etc.): _____

JOBS AND EDUCATION

List your last 3 employers:

EMPLOYER	CITY & STATE	YEARS EMPLOYED	JOB TITLE OR FUNCTION

List your college and university degrees:

SCHOOL	YEARS ATTENDED	DEGREE

Special Training _____

PERSONAL DATA

AGE ..... U. S. CITIZEN ☐ YES ☐ NO If not, when do you expect to become a citizen? .....

Name: .....

Home Address: .....

Home Telephone: .....

Make sure you have checked the companies you are interested in on the other side of this Form. Then put the Form in a stamped envelope and mail it to Space/Aeronautics.

What did you have in mind, Mr. Engineer?

Problems you can really get your teeth into? A job environment where there's *room* to think . . . and *grow?* A secure spot in a fast-growing organization where professional rewards come quickly? Excellent living conditions?

Raytheon Company's Bedford Laboratory offers all these. A key laboratory in the only electronics company with prime contracts for two major missile systems, the Bedford Laboratory is constantly expanding its programs . . . a growth shared by the men who staff it. What's more, it's located in the heart of New England, only minutes from Boston, where relaxed suburban living is only minutes from metropolitan attractions.

In short, Mr. Engineer, you'll *find* what you had in mind . . . at Bedford. Immediate openings for the following men. Can you qualify?

Send your postcard or letter to Mr. Jerry Morris, Professional Employment, Raytheon Company, Missile Systems Division, Bedford, Massachusetts. If you prefer, call (collect) CRestview 4-8884 and ask for Mr. Morris.

Data Handling Engineers with experience in high speed, analog-to-digital conversion techniques, logic design, converter and buffer design. Should have thorough knowledge of tape recorder techniques and digital, servo and digital-computer design.

Circuit Design Engineers with experience in design of high speed switching circuits, pulse techniques, and computer logic. Experience in one of the following areas required: design of navigation, guidance, control circuits, CCM, FM, PCM, PDM, and fusing circuitry.

Packaging Engineers with a knowledge of packaging and production techniques in sheet metal and electronic equipment. Will design electronic portions of guided missiles, radars, computers, test equipment. Thorough knowledge of circuitry required.

Electromechanical Designers will design electromechanical equipment and electronic portions of guided missiles. Will work closely with Design Engineers in developing electronic packaging philosophies. Knowledge of electronics, electronic components, and ability to read schematics required.

RAYTHEON MISSILE SYSTEMS DIVISION

. . . creates a climate for talent.

Check Employment Inquiry Form on Page 161

A New Role for The Mature Scientist

. . . in a unique Military Systems Organization

created by RCA The fundamental mission of RCA's newly organized Advanced Military Systems Department is to develop new systems concepts that will satisfy military operational requirements in the period beginning five years in the future. In the establishment of this new department, all problems—e.g. organization, personnel, support, operating practices, and relations with other RCA departments—have been approached and solved with the firm objective of optimizing the ability of Advanced Military Systems to fulfill its mission. The result is, we believe, a unique organization operating in a uniquely creative environment.

Members of the Technical Staff are mature scientists and engineers who operate either independently or in loosely organized teams. They have no responsibility for administrative details, but rather are kept unencumbered for either purely creative work or giving guidance to program implementation. They have, of course, full access to all available information —military, academic, and industrial. Investigations in support of their studies may be requested of appropriate RCA departments. In a word, they are provided with every opportunity and facility—all the resources of the vast RCA organization—to use their creative and analytical skills to maximum advantage and at the highest level.

In its wholly stimulating and challenging work, the Department operates at the very frontiers of knowledge in the physical sciences, mathematics, engineering, and military science, to develop advanced system concepts applicable to such military areas as

AICBM **UNDERSEA WARFARE**
LIMITED WARFARE **SPACE**

At the present time, there are a few openings for mature scientists, engineers, and mathematicians who have already attained recognition in their fields. If you have at least 15 years of education and defense *systems* experience beyond a bachelor's degree, in electronics, vehicle dynamics, physics, or operations research; if you are creative and interested primarily in working with pencil, paper, and imagination, we should like to hear from you. Please write to:

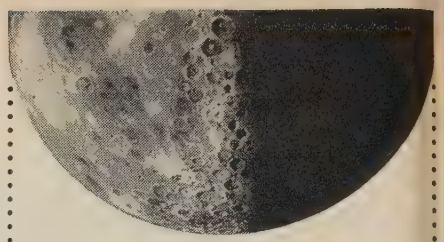
Dr. N. I. Korman, Director
Advanced Military Systems, Dept. AM-7B
RADIO CORPORATION OF AMERICA
Princeton, New Jersey

EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA

RADIO CORPORATION of AMERICA

Check Employment Inquiry Form on Page 161



THEORETICAL AND EXPERIMENTAL PHYSICISTS

Rocketdyne is expanding its electrical propulsion activities, openings exist for:

ION ROCKET ENGINE

Project Leader for Ion Thrust Device—Challenging position to direct the experimental research of a long-term development program on: Ion sources; Ion Species; Electrical discharge phenomena; Field phenomena; Ion acceleration and collimation; Sputtering; and Ion-electron recombination.

Senior Research Specialist—To conduct experimental research on: Auxiliary space powerplants; and Electrostatic generators.

Senior Research Specialist—To conduct analytical studies on: Ion beam dynamics; Direct Power conversion; and Electrical propulsion systems.

MAGNETOGASDYNAMICS

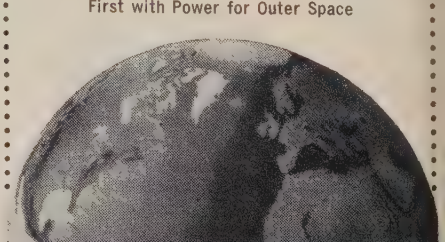
Senior Research Specialist—To conduct experimental and theoretical research directed toward development of a thermo-dynamic plasma jet for satellite and space propulsion.

Desired qualifications: MS or PhD degree and from one to five years of related experience.

Address inquiries to:
Mr. J. C. Peck
Dept. FB 596
6633 Canoga Avenue
Canoga Park, California

ROCKETDYNE

A DIVISION OF NORTH AMERICAN AVIATION, INC.
First with Power for Outer Space



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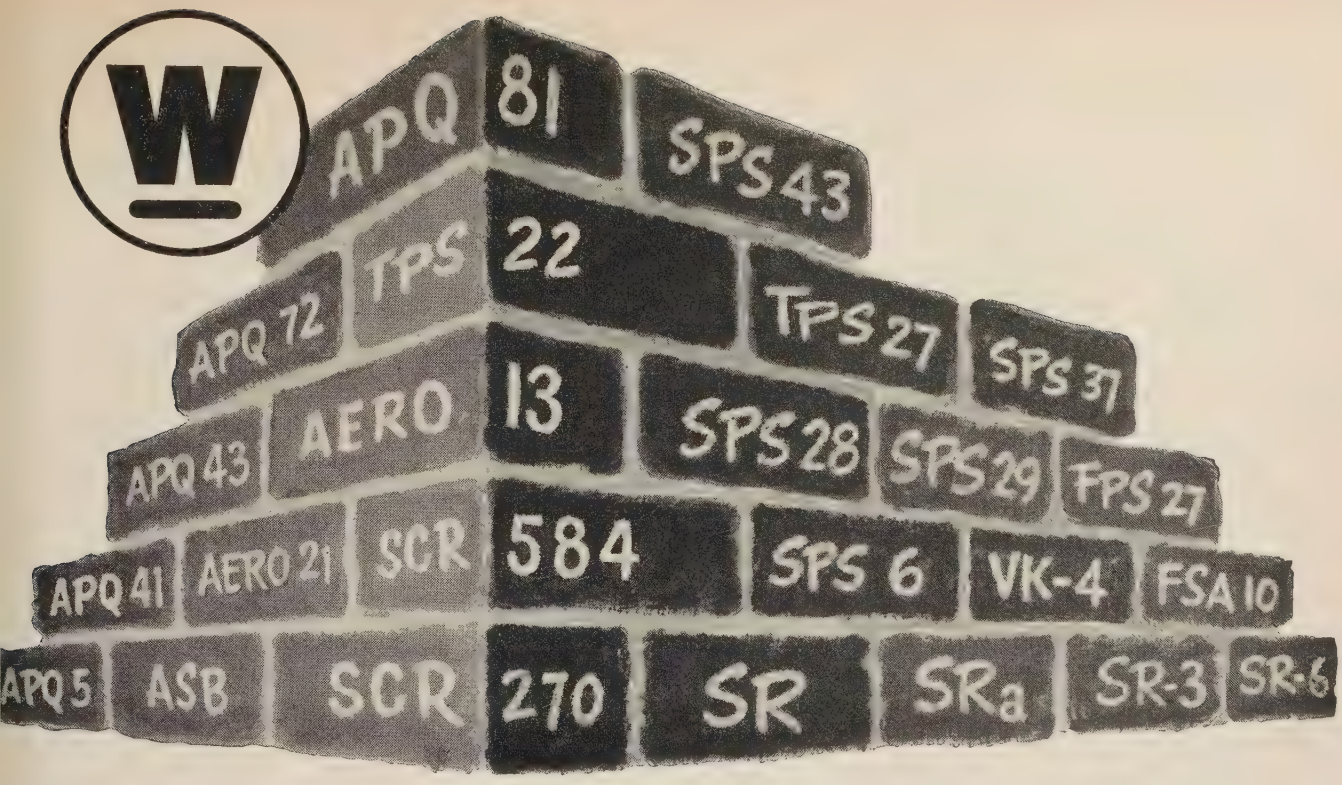


Build Your RADAR Career On This Solid Foundation!

The Weapons System Concept is one more step forward in a long series of "firsts" for the men who pioneered this field with the SCR-270, the first long range radar. In ground, shipboard and airborne radar, Westinghouse is the recognized leader in advanced programs and techniques. As Westinghouse builds new levels of accomplishment on this solid foundation, new career opportunities in radar development are created. Westinghouse-Baltimore invites inquiries from radar engineers with experience or interest in the following fields:

- **Operations Research and Analysis**
- **Systems Development and Evaluation**
- **Transmitter and Receiver System Development**
- **Advanced Antenna Systems**
- **Molecular Electronics**
- **System Synchronization**
- **Data Processing**
- **Liaison and Field Engineering**
- **Advanced Displays and Monitoring**
- **Network Synthesis**
- **Microwave Systems**
- **Systems Reliability Prediction**
- **Advanced Systems Automated Test**

SEND RESUME TO: Mr. A. M. Johnston, Dept. 232

Westinghouse

BALTIMORE

P. O. Box 746 Baltimore 3, Maryland

AIR ARM • ELECTRONICS • ORDNANCE

Check Employment Inquiry Form on Page 161

Diversification means many things to the people who are contributing their talents to Rohr's unchallenged role as the world's largest producer of components for flight. It means a variety of interesting assignments and the opportunity for personal growth and professional expression. Diversification has led to Rohr's record backlog of nearly a quarter billion dollars — 64 percent in *commercial* contracts — assuring unparalleled stability.

Rohr's diversification is symbolized by the jet power package pictured above, containing 5000 Rohr-built parts, and the Rohr-developed honeycomb brazing process shown below . . .

Rohr invites inquiries from men who can contribute to the company's continued leadership in the aerospace industry. Write to Mr. J. L. Hobel, Industrial Relations Manager, Rohr Aircraft Corp., P.O. Box 878-F, Chula Vista, California.

WORLD'S LARGEST
PRODUCER OF
COMPONENTS FOR FLIGHT

ROHR
AIRCRAFT CORPORATION

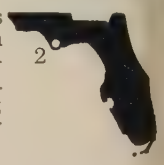
Chula Vista & Riverside, Calif.

Check Employment Inquiry Form on Page 161

new openings in Florida with Vitro

Vitro Laboratories' Florida operation, Vitro Weapons Services, is rapidly expanding its technical staff to operate the nation's newest missile test range, the EGLIN GULF TEST RANGE.

High level supervisory and staff opportunities exist at five Florida locations: 1. Fort Walton Beach; 2. Port St. Joe; 3. Tarpon Springs; 4. Naples and 5. Key West.



ELECTRONIC ENGINEERS — with degree(s) and several years experience in Automatic Tracking Radar, Electronic Instrumentation, Phase Comparison Space Positioning Systems, Data Recording and Conversion, Telemetry or Missile Range Instrumentation.

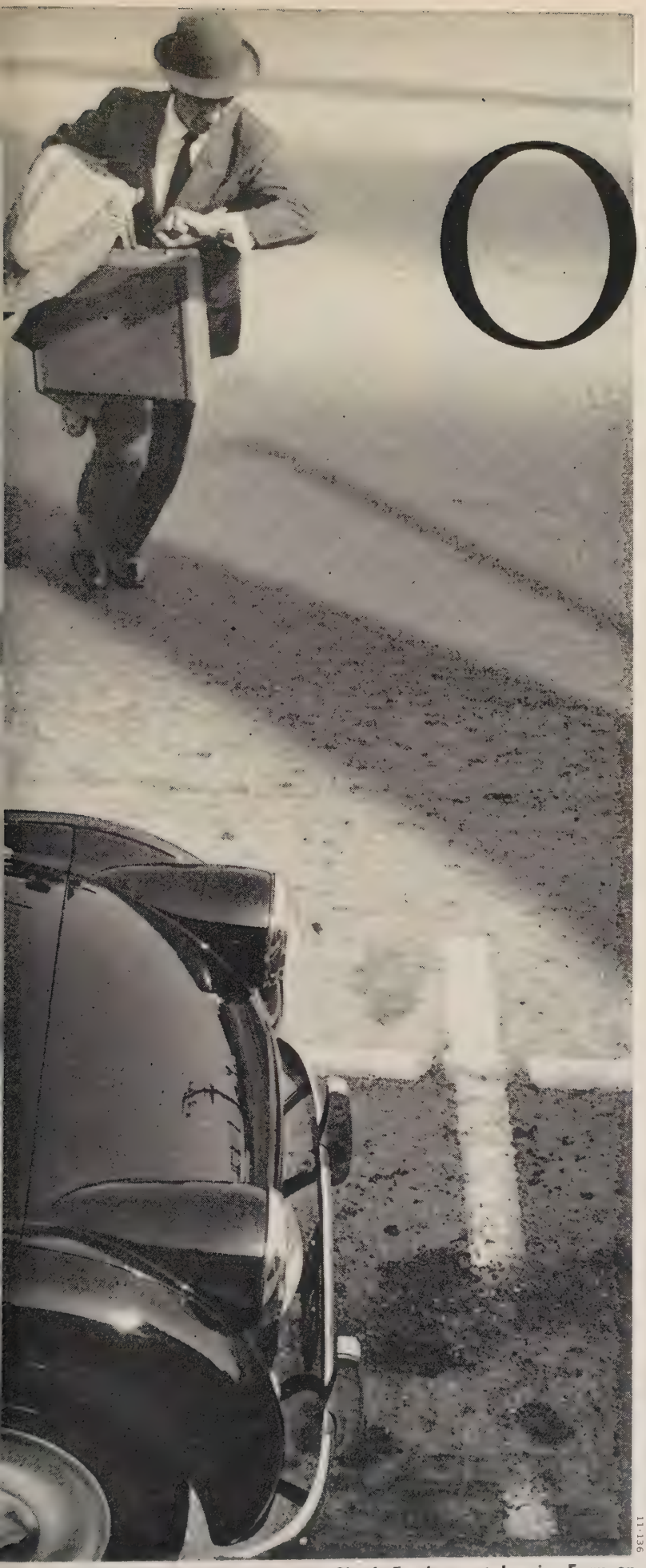
RADAR TECHNICIANS — with training and experience in one or more of the following radar systems: MSQ-1, MSQ-1A, FPS-16, Nike, M-33, MPS-9, SCR-584, CPS-6, FPS-3 and FPS-20.

ELECTRONIC TECHNICIANS — with a solid background in electronics and several years experience in Telemetry, Data Converters, Oscillograph Recorders or Range Electronic Instrumentation.

For your opportunity to relocate in Florida with an electronics industry leader, address a confidential resume to D. D. Cox, Personnel Director, Vitro Weapons Services, 119 East Main Street, Fort Walton Beach, Florida, Dept. SA.

Vitro
LABORATORIES
DIVISION OF VITRO CORPORATION OF AMERICA
Other laboratories at West Orange, N. J., and Silver Spring, Md.

Check Employment Inquiry Form Page 161



Operations Research Scientists:

Need time to develop your ideas?

Most scientists engaged in operations research work seem to feel that they cannot do their most productive work when they are constantly fighting unrealistic deadlines.

The operations research programs at System Development Corporation are carefully planned to provide ample time for the development of new ideas that apply to the development of large-scale, computer-based information-processing systems.

The following are just a few examples of the areas in which Operations Research Scientists work at SDC: (1) simulation and operations gaming techniques in problems of control systems; (2) mathematical logic applied to universal computer languages; (3) medical data processing; (4) stochastic modeling of man-machine interactions; (5) logistics; (6) test design for operational computer programs.

Operations Research positions are now open for scientists at several levels of experience. Please send your inquiry to Mr. E. A. Shaw, SDC, 2424 Colorado Avenue, Santa Monica, Calif.

"Application of Computer Simulation to Production System Design," a paper by Allen J. Rowe, is available upon request. Send request to Dr. Rowe at SDC.

SDC

SYSTEM DEVELOPMENT CORPORATION

Santa Monica, California • Lodi, New Jersey

Check Employment Inquiry Form on Page 161

The Engineering World's Your Oyster!

A world of electronic problems . . . yours to solve. A world of experience . . . yours to exploit. A world of fascinating locations . . . overseas, on the seas, in the nation's laboratories . . . yours to explore. A career unmatched for excitement, variety, professional stimulation—field engineering with RCA Service Company.

Present vacancies call for an engineering degree or equivalent, experienced in airborne systems, ground radio, navigational aids or data processing systems. Starting salaries to more than $10,000 with allowances while in the field. Overseas compensation may bring total income to $18,000 per year. A few vacancies in southeastern U. S. exist for engineers with experience in analysis of air defense systems, with a starting salary to $11,000 annually.

If you are an engineer, *on the move,* your future is with Government Service, RCA Service Company, a *growth* department of a *growth* company in a *growth* industry.

To arrange a confidential interview, send a complete résumé to:

Mr. J. H. Barnes, Jr.
Engineering Employment
RCA Service Company, Dept. Y-19B
Cherry Hill, Camden 8, New Jersey

EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA SERVICE COMPANY
A Division of Radio Corporation of America

Check Employment Inquiry Form on Page 161

ATTENTION ALL ENGINEERS

If you are seeking new job opportunities be sure to read all employment advertisements in this issue—both in this Special Section and throughout the magazine

RESEARCH OPPORTUNITIES
in

SPACE SCIENCES

The Space Technology Operations of Aeronutronic has immediate need for engineers and scientists who are interested in working in the stimulating and highly diversified field of space sciences. This West Coast division of Ford Motor Company has the newest facilities and most advanced equipment for carrying out highly technical work — challenging creative work that is exceptionally rewarding to qualified men.

Positions are at Aeronutronic's new $22 million Research Center, being completed at Newport Beach, Southern California. Here, overlooking famous Newport Harbor and the Pacific Ocean, relaxed California living can be enjoyed free of big-city congestion, yet most of the important cultural and educational centers are just a short drive away.

AREAS OF INTEREST

VEHICLE TECHNOLOGY
Aerodynamic design and testing
Rocket Nozzle and re-entry materials
High temperature chemical kinetics
Combustion thermodynamics
High temperature structural plastics and ceramics
Advanced structures

SYSTEMS DEVELOPMENT
Aerothermodynamics
Re-entry programs
High temperature heat transfer
Penetration systems
Hyper environmental test systems

ELECTRONICS AND ASTRO SCIENCES
Astro navigation
Space communications and communication satellites
Instrumentation, telemetering and data reduction
Space environmental physics
Advanced techniques and system studies

TACTICAL WEAPON SYSTEMS
Infrared systems • Transistor circuit development

Qualified applicants are invited to send resumes and inquiries to Mr. G. B. Eaton, Aeronutronic, Dept. 11, Box 451, Newport Beach, California.

AERONUTRONIC
a Division of Ford Motor Company
Newport Beach
Santa Ana • Maywood, California
Natick, Massachusetts

Check Employment Inquiry Form on Page 161

ENGINEERS:

FACTS WITHOUT FRILLS...

About Job Potentials at Light Military Available to You Now!

Prepared for the engineer who likes to get right down to basics in evaluating a position, LMED's Fact Sheets bring you clearly presented up-to-date unvarnished information about all the aspects of company policies, projects and plans related to your professional future here.

WHETHER OR NOT YOU CONTEMPLATE AN IMMEDIATE CHANGE, these "Engineering Fact Sheets" are a valuable thing to have. Use them as a yardstick to assess your present – or a possible future – association.

Next to your choice of profession, and your choice of a wife – selecting a position with long-range career implications can be the most important decision in your life...

It's A Good Thing To Have Reliable Tools On Hand, To Help Make That Choice a Sound One!

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Organization
Size of Staff
Resources
Facilities List
Technical Scope (list of projects)
Internal Communications and Support
Benefits (detailed)
Salary Scale
Specific Responsibilities of D&D Engineer
Promotion Plan
Graduate Program
In-Plant Courses
Contacts with Other G.E. Components

SEND FOR THESE "ENGINEERING FACT SHEETS"

Mr. R. Bach / Light Military Electronics Department /
General Electric Company / French Road, Utica, New York.
Please send me a set of your "ENGINEERING FACT SHEETS."

NAME_____

HOME ADDRESS_____

CITY_____ ZONE_____ STATE_____

DEGREE(S)_____ YEAR(S) RECEIVED_____

60-MB

LMED
LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC
FRENCH ROAD, UTICA, NEW YORK

Check Employment Inquiry Form on Page 161

New Gateway to Achievement in Astronautics and Aeronautics

Republic Aviation's *New* Research & Development Center

Engineers and scientists whose minds are challenged by unsolved problems across the entire spectrum of technologies concerned with space exploration and upper atmosphere flight, are invited to inquire about the exceptional facilities for both theoretical and experimental investigations provided by Republic's new Research and Development Center (scheduled to open Spring 1960).

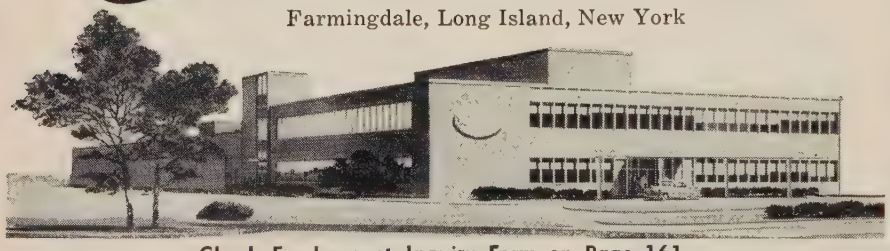
Senior level openings exist in the following areas:

Space Electronics *(Guidance, Navigation, Communications)* / Hydromagnetics / Advanced Computer Technology / Applied Mathematics / Nuclear Power Packages / Space Environmental Studies *(Life Science)* / Celestial Mechanics / Hypersonics / Electronic Theory / Plasma Physics / Radiation Studies / Re-entry Techniques / Materials Research & Development / Fluid Mechanics

Please forward resumes to: Mr. George R. Hickman
Technical Employment Manager, Dept. 6B

REPUBLIC AVIATION

Farmingdale, Long Island, New York



Check Employment Inquiry Form on Page 161

IMPORTANT

In filling out "Employment Inquiry Form" be sure to print clearly. When you check more than one company, the form must be photostated so that each company receives a copy.

BENDIX-PACIFIC

in Southern California

needs ENGINEERS *with*

DOCTORS'-MASTERS'-BACHELORS'

DEGREES

for electrical, mechanical and systems work in fields of Instrumentation—Telemetry

Anti-Submarine Detection Systems/Operations Research

Missile and Aircraft Fluid Controls.

Please send resume to MR. RALPH LAMM,
DIRECTOR OF ENGINEERING

Other High-Level Electronic Engineering Positions Available

Bendix-Pacific
DIVISION OF BENDIX AVIATION CORPORATION
NORTH HOLLYWOOD, CALIFORNIA

Check Employment Inquiry Form on Page 161

Now offering...
creative careers in ordnance

Expanding operations in an exciting, growing company have created unusual career opportunities for ordnance engineers. Assignments on research and development projects will require the mature judgement of from two to ten years' experience in the field and present a combination of stimulating challenge and an ideal professional climate for contribution and personal development.

The company: the Crosley Division of Avco Corporation. There, confidence and personnel morale stem from aggressive management, a progressive approach to individual effort, and maximum support for all projects.

Definite creative career opportunities are available now. Experienced personnel can choose from:

- Ballistics
- Arming and Fuzing
- Non-nuclear Weapons Systems Analysis
- Target Damage Evaluation
- Warhead Design
- Shells System Design
- Microminiature Electronic Assemblies Design
- Projectile Design

For complete information, write or call: Mr. P. B. Olney, Manager of Scientific and Administrative Personnel Dept. C-20, Crosley Division, Avco Corporation, 1329 Arlington Street, Cincinnati 25, Ohio. Phone: KIrby 1-6600.

Avco / Crosley

Check Employment Inquiry Form Page 161

Systems Engineers . . .

Take a

GIANT STEP

with RCA's

AIRBORNE SYSTEMS DIVISION

This far-reaching activity is involved in engineering development, design, and manufacture of all types of airborne—*and* undersea—electronic systems and equipment. Current projects necessitate conception of several complete weapon system support units (including missile and outer-space gear), communications, electronic warfare, and undersea warfare systems.

As an RCA systems engineer, you will not only be responsible for creating some of today's most vital strategic defense weaponry . . . but will be able to advance rapidly, *as an individual*, on a highly liberal merit basis. This is an extremely unusual growth situation. To keep you free for only *creative* activities, a vast array of well-staffed, well-equipped facilities —both research and manufacturing—are on hand to support you at all times.

A select number of openings now exist for systems engineers and operations research personnel with broad experience in military systems. If you qualify . . . and are ready to take a giant step forward in your *professional* career . . . please send a résumé to:

Mr. C. B. Gordon, Dept. SA-20
Professional Placement Office
RCA, Bldg. 10-1
Camden 2, New Jersey

EQUAL JOB OPPORTUNITY For All Qualified Applicants

RCA ®

RADIO CORPORATION of AMERICA
DEFENSE ELECTRONIC PRODUCTS

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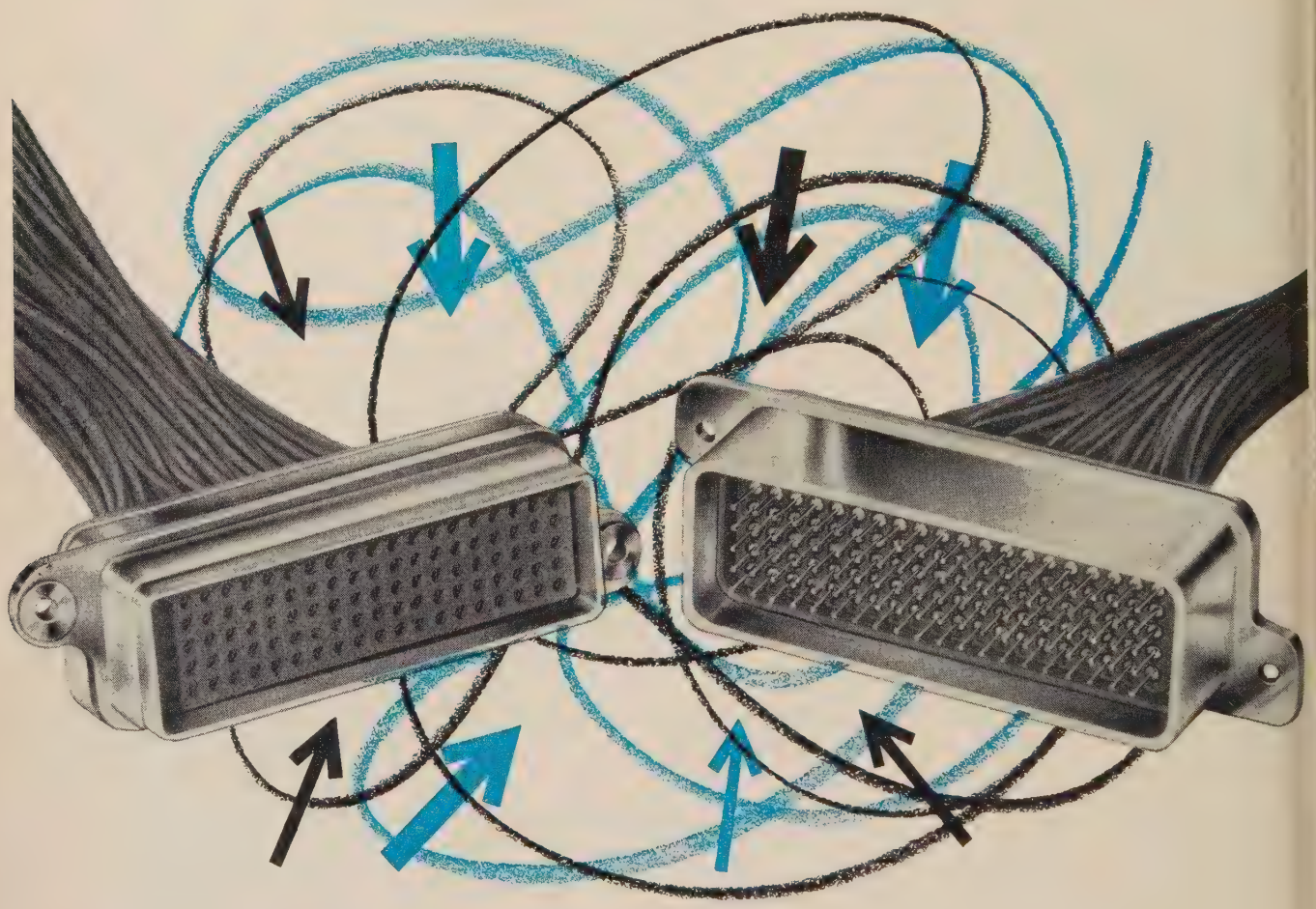
WHEN THE DUTY'S ROUGH AND THE CIRCUITS ARE CRITICAL



***AMPin-cert* RACK AND PANEL CONNECTORS**—Here's a rack and panel connector that can really take a beating and keep right on going . . . performs like a champion in the toughest environments, with the roughest treatment yet gives enduring critical-circuit performance.

Environmentally sealed or unsealed, *AMPin-cert* connectors are made in 50 and 100 position units and have a number of unusual features including: single or dual circuit leads per contact (in the 50 position unit) . . . crimp-on snap-in contacts with extra wire insulation support against vibration . . . aluminum shells for shock . . . cadmium plating for corrosion resistance . . . extended alignment skirts plus alignment bushings on shells to prevent coupling damage to contacts . . . alpha-numerical coding of all cavities.

Get reliable performance under vibration and shock . . . in arid climates . . . in excessively humid conditions . . . in extreme cold or heat. No solder, naturally. Current rating of 5 amperes.

If you need a rugged connector with dry circuit sensitivity, the *AMPin-cert* Rack and Panel Connector is your answer. Send for more information today.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Japan

Write in No. 105 on Reader Service Card at start of Product Preview Section

product index to advertising

THIS IS A SPECIAL REFERENCE to the product information given in the advertisements in this issue. It is intended solely to help the reader make the best use of these ads. Therefore the index does not necessarily cover all the products made by each advertiser. Also, definitions and cross-listings are not intended to exhaustively describe each product but merely to make sure that each product can be found with reasonable ease by the reader looking for it.

Similar indexes to services and employment opportunities featured in ads follow this index.

Advertisements for which complete proofs were not available to the Editorial Department by the closing date are not necessarily covered by these indexes. (Proofs can be forwarded internally by the Production Department only for advertisements meeting the closing dates.)

For more detailed information on any product or service advertised in this issue or featured in its Product and Data Reviews, use the handy Reader Service Card.

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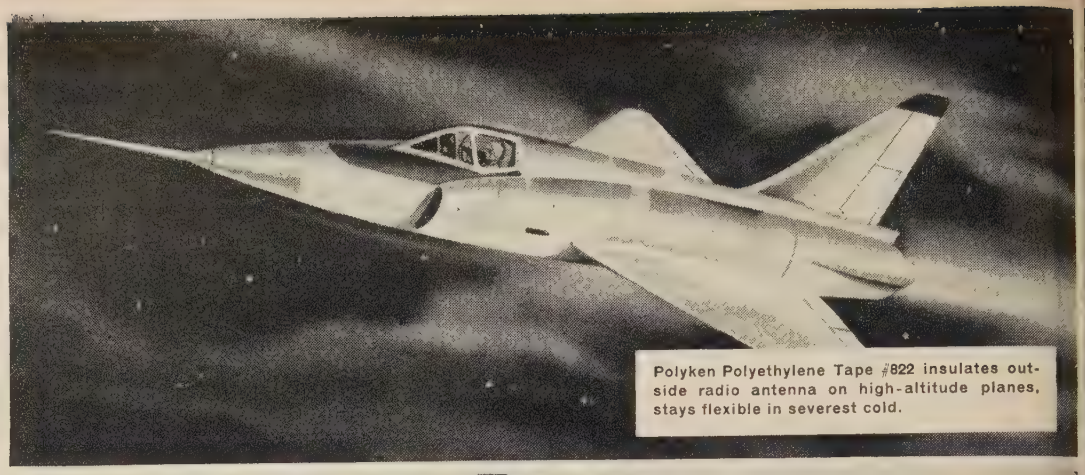
Whatever the condition...



Polyken Polyethylene Tape #822 insulates outside radio antenna on high-altitude planes, stays flexible in severest cold.

the climate...

"Big Inch" pipeline wrapped in Polyken Protective Coating Tape withstands 120° heat of Iranian desert, resists corrosion.

the job...

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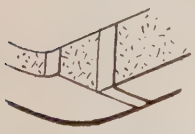
PROTECTING • PACKAGING • REINFORCING • MASKING
HOLDING • BONDING • SPLICING • HEAT-SEALING

There's a Polyken Tape to solve your problem

A jet slices through the thin stratospheric air in −70° F. cold. A pipeline carries precious oil across miles of desert waste under a broiling sun. Both do their jobs helped by modern Polyken tapes.

Within this complete and versatile line are tapes that can solve your particular problem regardless of climatic extremes of temperature and humidity, under severe conditions of stress and corrosion. Tapes designed for dozens of uses in thousands of areas of production, packaging, and shipping. For the tape-answers to *your* needs, phone your nearest Polyken Industrial Tape Distributor. Or write to Polyken Sales Division, Dept. SA-2, 309 W. Jackson Blvd., Chicago 6, Illinois.

Three of a Thousand Ways Polyken Can Work for You:



Polyken Fiberglas Tape effectively seals heating duct joints despite constant high temperatures.

Polyken Waterproof Packaging Tape protects drums of costly pharmaceuticals from water, air, dust.

Polyken Surface Protection Tape guards "soft" plexiglass cockpit canopy, yet comes off clean and easy.

Polyken®

INDUSTRIAL TAPES

THE KENDALL COMPANY
Polyken Sales Division

Write in No. 106 on Reader Service Card at start of Product Preview Section

Here's a *NEW* FILTER ELEMENT that *FORBIDS* MEDIUM MIGRATION

From SKINNER — a name famous in filtration since 1927 — comes a unique, high temperature filter element for high performance aircraft and missile applications. A unique acid resistant braze and fabrication method whips the problems of acid compatibility and restricted temperature ranges. Temperature limits are from —400 F to 1800 F in continuous fluid-operating ranges. *No filter medium migration.* A smaller envelope is another advantage of this highly efficient element. Any type of housing applicable and delivery is immediate. If you have a filtering problem, write Skinner . . .

SKINNER FILTER

DIVISION OF

hydrodyne CORPORATION

7350 Coldwater Canyon, No. Hollywood, Calif.
Phone: POplar 5-8001

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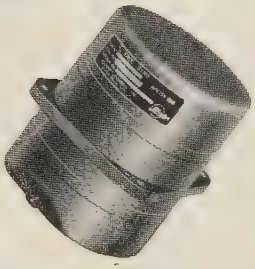

FREE GYRO

A highly reliable, two-degree-of-freedom instrument utilizing AC synchro transmitters at each gimbal axis. Designed to operate under the most severe missile conditions, this gyro has AC torquers mounted at each gimbal axis to permit command positioning or slaving of spin axis to desired reference position; each torquer capable of producing a precession rate of 360°/minute with 12.5 watts/phase power input.

TYPICAL CHARACTERISTICS #Q2315

Environmental Capabilities
- Temperature Range: (operative): —54°C to +71°C (non-operative): —65°C to +85°C
- Altitude: Unlimited
- Vibration: 10g, 10-2000cps

Pickoffs
- Excitation: 26V, 400 cps, single phase
- Output (sinusoidal): 11.8V ± 5% max.
- Error from E.Z.: 10 min. max.

Motor
- Excitation: 115V, 400 cps, three phase
- Speed: 23,500 RPM
- Momentum: 2.25 x 10^6 gm cm^2/sec.

Caging and Preset Provision (Electrically energized torquer type)
- Excitation: 115V max./phase
- Torquer Constant: 22.8 dyne cm/$Volt^2$

Performance Characteristics
- Free Drift: 5°/minute each axis
- Runup Time: 1 minute max.
- Torquing Rate: 360°/min. (intermittent) 40°/min. (continuous)

Write for complete data.

KEARFOTT DIVISION

GENERAL PRECISION INC.

LITTLE FALLS, NEW JERSEY

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Air France jets were flying before Gigi was born!

Gigi is six. Yet it was *more* than six years ago (February 19, 1953, to be exact) that Air France began flying regularly scheduled pure jet aircraft!

Since then, Air France has logged over 4 million jet passenger miles. First, with the sleek, vibrationless, 500-mile-an-hour Caravelle. And now, Air France has added the fabulous new Boeing 707 Intercontinental to its fast-growing pure jet fleet. The Intercontinental is the world's fastest, largest, longest-range jetliner crossing the Atlantic non-stop between New York and Paris in only 6½ hours.

The Boeing 707 Intercontinental is the most thoroughly tested airliner in aviation history. First, with thousands of hours of testing on the ground; then, more thousands of hours of actual flights.

Yes, Air France jets were flying before Gigi was born. A reassuring fact to remember whenever you fly overseas on *the world's largest airline.*

AIR FRANCE JET

WORLD'S FASTEST JETLINER / WORLD'S LARGEST AIRLINE

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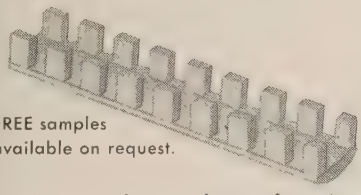
"pipcats" have 9000 lives

Pipco's Nylon Caterpillar Grommet

...THE PIPCAT

More and more design engineers are discovering *PIPCATS*...new nylon caterpillar grommets by Pipco! The grommets can fit any size or shape hole without cement. They're U.L. approved — an excellent insulated bearing surface around sheet metal holes — conforming to any metal thickness, even oversized or undersized pieces. *PIPCATS ARE TOUGH*. They're made of abrasion-resistant nylon, give durable protection and withstand high heat. *PIPCATS ARE FLEXIBLE*. They're adaptable to innumerable applications and can be cut to any size desired.



FREE samples available on request.

Design engineers have found a wide variety of uses for Pipcats in many fields including home appliance, electronics, aircraft and missiles, sheet metal, automotive and air conditioning.

small parts with a BIG reputation

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Industrial Parts Manufacturing Division
PLASTIGLIDE MANUFACTURING CORP.
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Santa Monica, California

EXmont 3-3744

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BASIC BUILDING BLOCKS FROM KEARFOTT

VERTICAL GYRO

Kearfott's rugged new vertical gyro, designed for missile application, is a two-degree-of-freedom instrument with 360° of freedom about inner gimbal axis. Self-contained vertical erection system incorporates liquid bubble-type vertical sensing device.

TYPICAL CHARACTERISTICS #B2115

Environmental Capabilities
Vibration:
5 g, 20-1000 cps;
10 g, 1000-2000 cps
Temperature Range (operative):
—54°C to +71°C
(non-operative):
—65°C to +85°C
Altitude: Unlimited

Pickoffs
Excitation:
26V, 400 cps, single phase
Error from E.Z.: 10 min. max.
Output Voltage (line to line):
11.8V ± 5% max.

Motor
Excitation:
115V, 400 cps, three phase
Power: Starting: 35 watts
Running: 7.5 watts

Performance Characteristics
Repeatability of Established Vertical:
To within a cone of half angle equal to 12 minutes of arc
Scorsby Drift Rate in 5 Min. Time:
0.3°/min. (average)
Erection Rate:
Normal: Between 2° and 4°/min.
Fast: 80°/min. intermittent, 40°/min. continuous

Physical Features
Anisoelastic Drift:
0.08°/min/g² at resonance
Weight: 5.5 lbs. (approx.)
Mass Unbalance: 0.1°/min/g

Write for complete data.

KEARFOTT DIVISION
GENERAL PRECISION INC.
LITTLE FALLS, NEW JERSEY

Write in No. 111 on Reader Service Card

gpl data handling

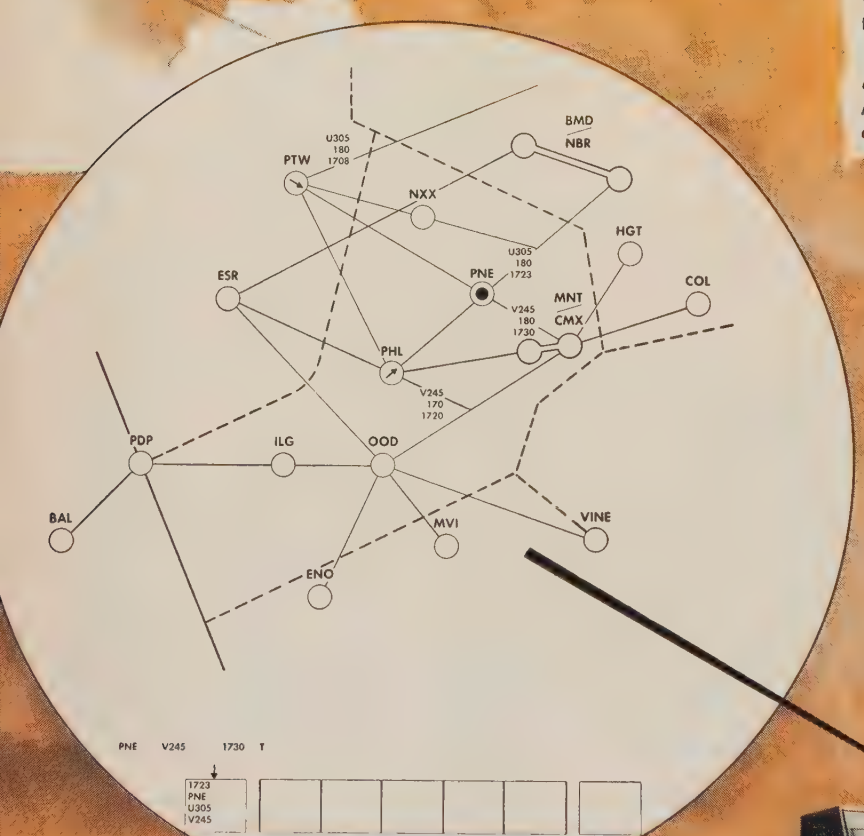
equipment for the Federal Aviation Agency

GPL's experience and ingenuity are at work assisting the FAA Bureau of Research and Development in the creation of a modern data processing central, the heart of tomorrow's air traffic control system. The central will receive up to 400 aircraft flight plans hourly, "remember" 1,000 such plans simultaneously and transmit 200 plans and 800 updates hourly to adjacent centers. Automatic processing and unique displays of such data will make significant contributions to the efficient control of aircraft in en-route, transition and terminal areas.

The FAA data processing central is just one of a number of airborne and ground-based programs reflecting GPL's capabilities in the data handling field. These programs are supported by GPL's proven ability to understand the customer's problem and capacity to anticipate future requirements. The GPL organization is "systems oriented," offers complete capabilities ranging from research, engineering and manufacturing to customer service.

Why not put these broad capabilities to work on your problem?

GPL Avionic Division/airborne navigators/missile guidance/radar/airborne computers/data handling systems/communications equipment/infra-red/closed-circuit TV.



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ENGINEERS — GPL achievements have opened some unusual research and development opportunities. Send resume to Personnel Director.

GPL DIVISION

GENERAL PRECISION INC.

PLEASANTVILLE, NEW YORK

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uncommonly versatile

The application of solid propellants and explosives to devices requiring reliable actuation is Pyronetics' specialty. The valve illustrated, Model 1006-1, shows one of the many uses of explosive actuation. It is a 2½", normally closed valve, for RFNA service; the valve is reusable, and intended for ground test use in a liquid propellant rocket engine.

Leak-proof, one-shot valves are available in many sizes — each characterized by low pressure drop and light weight.

write for bulletin no. 59EAV

Pyronetics
11973 E. Slauson
Santa Fe Springs, Calif.
OXbow 6-3710

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BASIC BUILDING BLOCKS FROM KEARFOTT

DIRECTIONAL GYRO

This compact new gyro, designed for application in high-performance aircraft and missiles, provides extremely accurate attitude data. Its liquid bubble-type vertical sensing element generates error signals proportional to spin axis displacement from horizontal, while minor wiring modifications permit sensor connection to leveling torquer, completing inner axis leveling loop.

TYPICAL CHARACTERISTICS #A2215

Environmental Capabilities
Vibration:
5g, 20-1000 cps; 10g, 1000-2000 cps
Temperature Range (operative):
—54°C to +71°C
(non-operative):
—65°C to +85°C
Altitude: Unlimited

Azimuth Pickoff
Excitation:
26V, 400 cps, single phase
Output (sinusoidal):
11.8V ± 5% max.
Error from E.Z.: 10 min. max.

Motor
Excitation:
115V, 400 cps, three phase
Speed: 23,500 RPM
Power: Starting: 35 watts
Running: 7.5 watts

Performance Characteristics
Drift: 4°/hr. max.
Leveling Rate:
Between 2° and 4°/min.
Azimuth Torquing Rate:
360°/min. (intermittent)
40°/min. (continuous)

Write for complete data.

KEARFOTT DIVISION
GENERAL PRECISION INC.
LITTLE FALLS, NEW JERSEY

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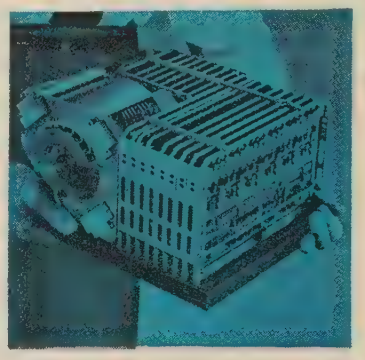
LIBRASCOPE MISSILE COMPUTERS

To the moon and back and wherever missiles fly, Librascope computers deliver ready answers for in-flight control ■ guidance, optimum trajectories, impact prediction, data reduction and analysis. Throughout flight...Librascope missile computers are uninterrupted by environmental extremes...and they will automatically and continuously check their own built-in accuracy. The compact size, minimum weight and performance of Librascope missile computers have earned them important roles in our conquest of space. For information on how Librascope advanced computer capabilities can answer your particular needs, write to Librascope, 808 Western Ave., Glendale, California. ■ Librascope, A Division of General Precision, Inc. ■ For information on career opportunities, contact Glen Seltzer, Employment Mgr.



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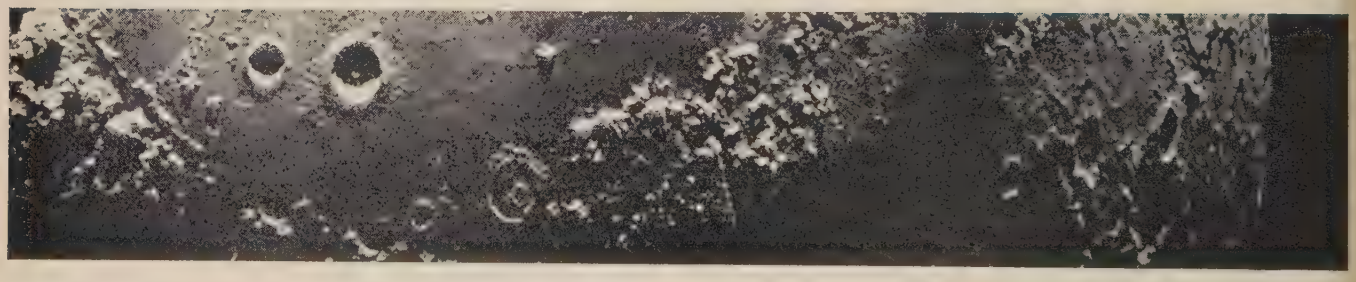
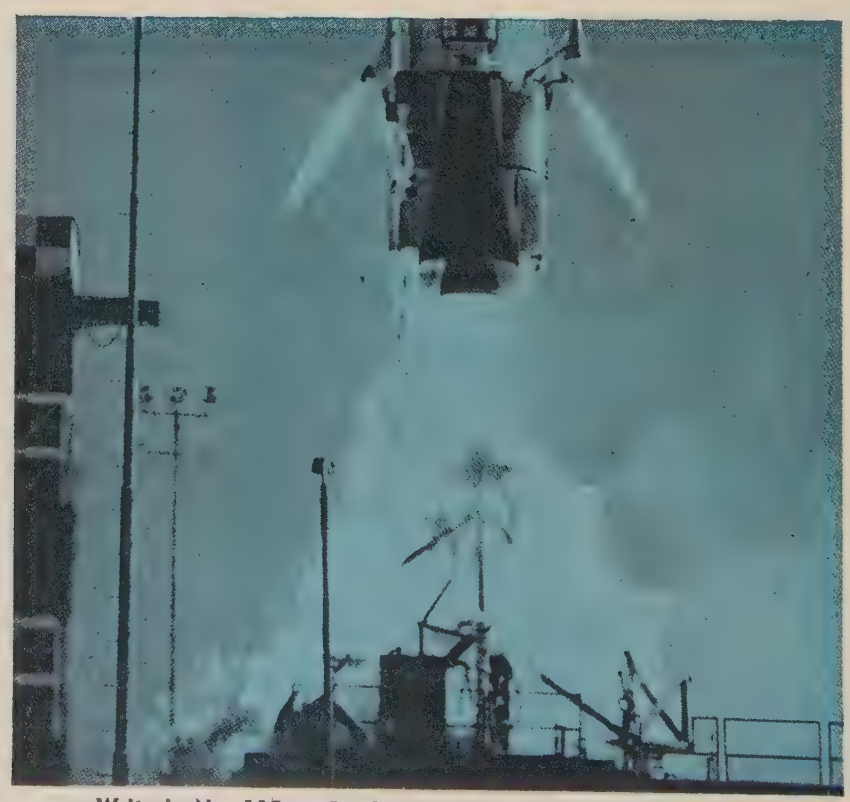


computers that pace man's expanding mind



LI 0-1

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BASIC BUILDING BLOCKS FROM KEARFOTT

SIZE 11 SYNCHRONOUS MOTOR

Featuring pull out torque efficiency of 50% nominal with 3.4 watts input and 3 watts pull out power, this synchronous motor represents a major achievement in terms of performance for a unit of this extremely small size. Additional advantages made possible by Kearfott's unique design include resistance to environmental extremes, light weight construction and low unit cost. This motor and its variations are available in production quantities.

TYPICAL CHARACTERISTICS R172

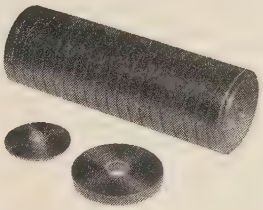
Excitation:	Phase 1	Phase 2
Voltage	40V	40V
Frequency	400 CPS	400 CPS
Power	2.3 Watts	2.3 Watts
Current	0.157 Amps	0.157 Amps

Performance:

Synchronous Speed	8000 RPM
Stall Torque	0.2 In. Oz.
Pull Out Torque	0.35 In. Oz.
Pull In Torque	0.15 In. Oz.

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



FERRITES

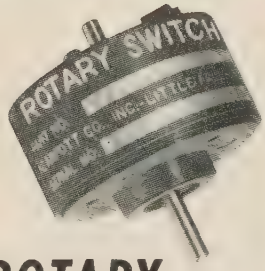
Kearfott's Solid State Physics Laboratory formulates, fires and machines permanent magnet ferrite materials of various compositions. Typical high-efficiency array utilizes Kearfott PM-3 ferrite material with specially designed pole pieces to produce a design both smaller and lighter than other arrays of equivalent magnetic field strength. Because magnets may be custom engineered to specific requirements, user is not restricted to stock magnet types, thereby providing greater latitude in parameters for focusing arrays. Pole pieces may also be provided according to specification, with the added assurance that, because of special Kearfott design techniques, B axial magnetic fields approximately 10% higher than those generally obtained in standard types may be produced.

TYPICAL CHARACTERISTICS

Peak Magnetic Field Strength	1200 gauss
Period	0.560 in.
Length	5.64 in.
Inside Diameter of Pole Pieces	0.400 in.
Outside Diameter	2.0 in.
Weight	3.2 pounds

Write for complete data.

BASIC BUILDING BLOCKS FROM KEARFOTT



ROTARY SWITCH

Kearfott's rotary switching devices for missile and aircraft systems are used to sequence or switch circuitry as a function of time or shaft position. Used in conjunction with sensitive relays or solid state switching techniques, high current loads can be handled. These switches consist primarily of shaft assembly and bearing mounted cylinder divided into conducting and non-conducting segments with continuous track for common input. Multiple conductor "broom" type brushes ride on each cylinder track while number of tracks and segmentation of each is function of the number of circuits and type of "on-off" sequencing required.

TYPICAL CHARACTERISTICS P1280-11A

Number of switching tracks: 2

Angular Segmentation (both referenced to 0° start):
Track 1 — Non-conducting about 0° + 50°
Track 2—Conducting 0° -180°
Non-conducting 180° -0°

Mechanical Accuracy of Segmentation:
±1° (better as required)

Starting and Running Torque:
0.1 oz.-in.

Current Capacity:
50 ma at 28V/Brush (suitable for any sensitive relay or solid state switching circuits)

Write for complete data.

Free Gyro

Vertical Gyro

Directional Gyro

Engineers: Kearfott offers challenging opportunities in advanced component and system development.

KEARFOTT DIVISION

GENERAL PRECISION INC.

LITTLE FALLS, NEW JERSEY

Midwest Office. 23 W. Calendar Ave., La Grange, Ill.
South Central Office. 6211 Denton Drive, Dallas, Texas
West Coast Office. 253 N. Vinedo Avenue, Pasadena, Calif.

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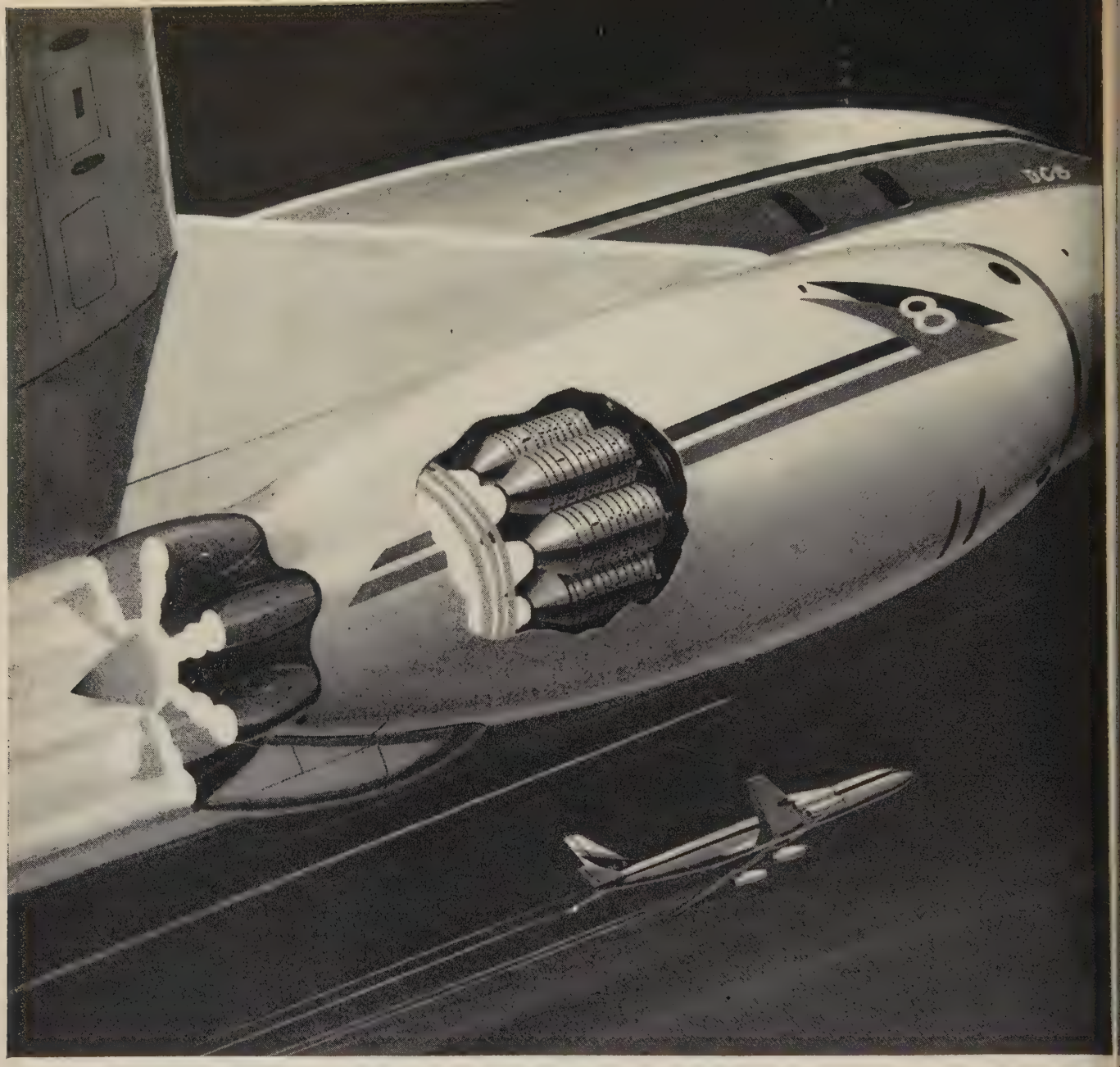

Inconel combustion chamber liners provide long service life in the jet engines that speed modern United Airlines DC-8's.

Inconel liners handle the power that speeds United Airlines' new jet fleet

Jet engines that generate power for modern aircraft, generate hot problems in combustion chambers.

Chamber liners go to red heat. The roaring gases produce severely oxidizing conditions.

Inconel* nickel-chromium alloy linings, shown in a DC-8's jet engine above, easily handle the heat, the oxidizing, corrosive attack of hot gases. Retain useful strength, too.

Proof?

Inconel liners in JT-3** jet engines have given nearly 3 *million* hours of dependable performance...under every conceivable operating condition.

Inconel liners also serve dependably in larger JT-4** jet engines, also used in some DC-8's.

On the production line, Inconel alloy pays dividends, too. Ductility enough for complex forming, drawing operations. Good weldability.

Nationwide Availability

Inconel alloy is available in all common mill forms from warehouse stocks across the country.

If you're looking to solve special problems involving heat and corrosion, look to Inconel alloy. Write us for more specific information.

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

*Inco trademark. **JT-3 and JT-4 engines are produced by Pratt & Whitney Aircraft Div. of United Aircraft Corporation, Hartford, Conn.

INCONEL®

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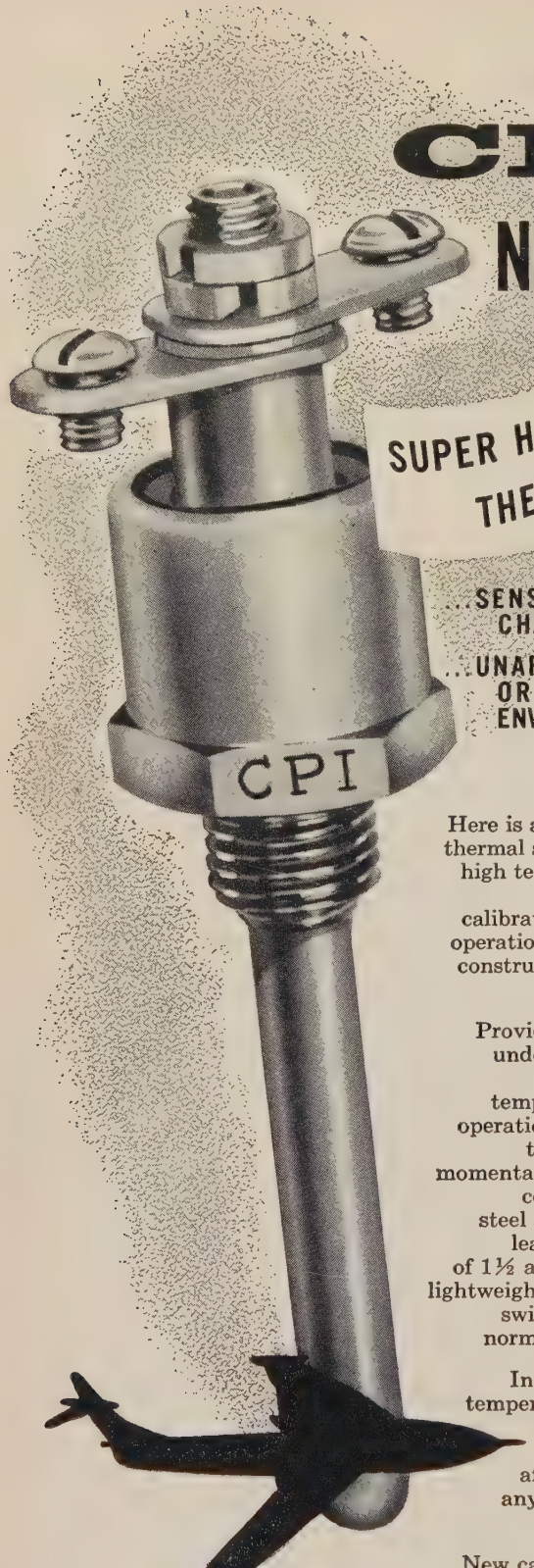

CPI's NEW DESIGN

SUPER HIGH TEMPERATURE THERMAL SWITCH

...SENSITIVE TO TEMPERATURE CHANGE ONLY

...UNAFFECTED BY VIBRATION OR OTHER ENVIRONMENTAL CONDITIONS

Here is a new super high temperature thermal switch designed for extremely high temperature applications where very high, close temperature calibration is required with repeated operations. And, its rugged, compact construction provides high resistance to vibration.

Providing a fast, accurate response under extreme service conditions, this *new design* switch has a temperature range for continuous operation from as low as minus 20°F to as high as 1750°F with safe momentary overshoots to 2200°F. It is constructed of special stainless steel alloys with single or two wire leads, and has a resistive rating of 1½ amperes at 28 volts D.C. This lightweight (it weighs only two ounces) switch is available with contacts normally open or normally closed.

Investigate this CPI super high temperature switch — applicable to such uses as jet engines, gas turbines, rocket motors, after burner control — in fact, anywhere that high temperature control is a problem.

New catalog gives engineering data. Ask for Catalog.

When temperatures are high (or low), specify CPI.

Control products, inc.

709

HARRISON, N. J.

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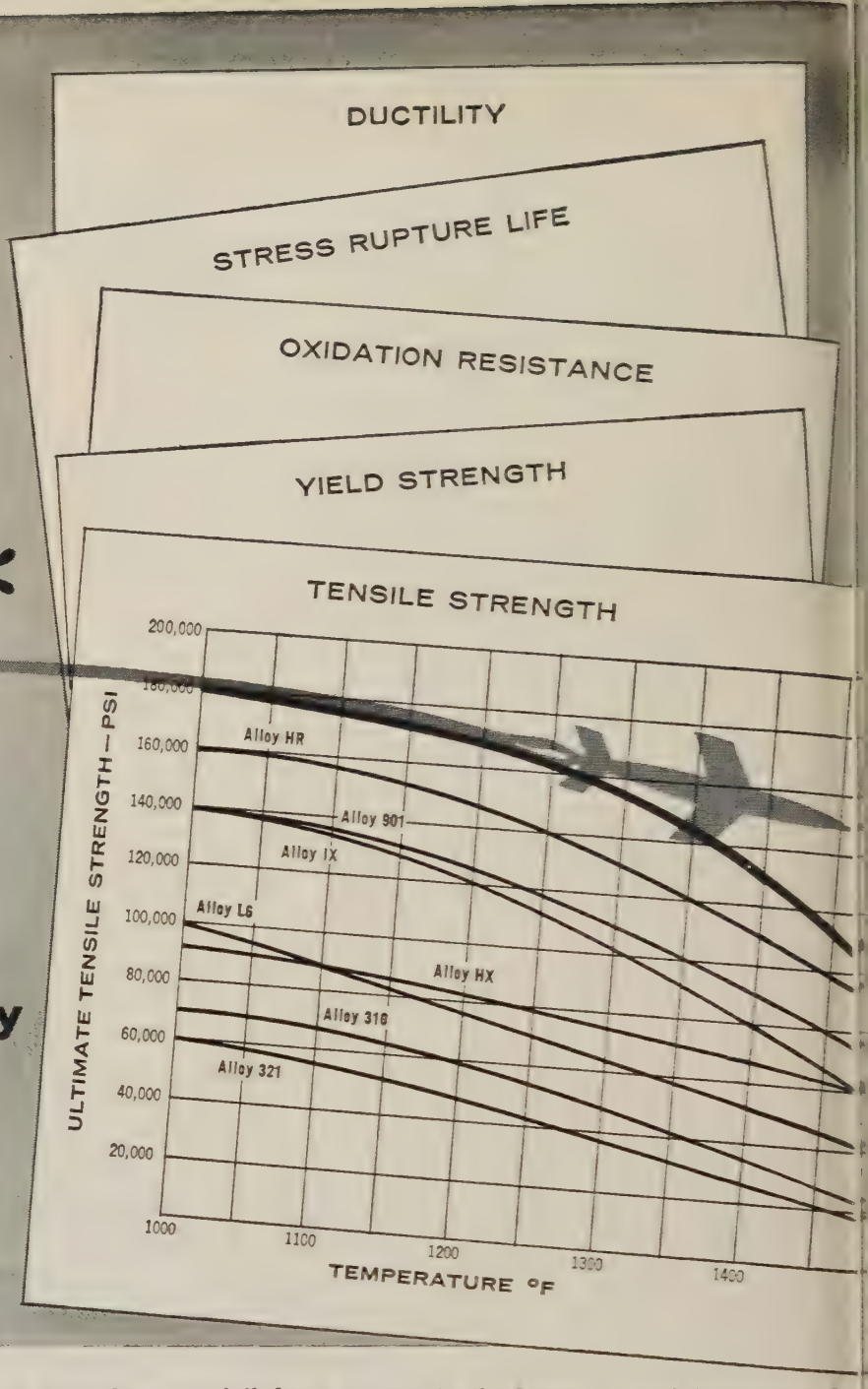
HIGH

on every chart:

RENÉ 41*

most dependable alloy in use today in the 1200°-1800° F range



In *all* ways, René 41 is a remarkable alloy. No other high-temperature alloy used in production today equals its tensile strength. In other properties, too, René 41 is far ahead of the field.

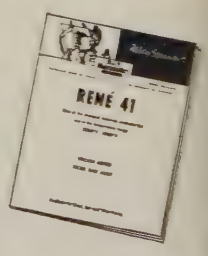
Also important, this nickel-base, vacuum-melted alloy is easy to work with. It's readily formable by drawing, bending, spinning — welds to similar or dissimilar materials.

Cannon-Muskegon offers René 41 in standard 36"x 96" sheets .015" to .125" thick, in smaller sizes down to .010", in bar stock up to 3" in diameter . . . foil down to .001 in thickness . . . and fine wire only .0015 in diameter.

For complete details, write for Technical bulletin No. 86.

*TM of General Electric Co.

ULTRAMET
VACUUM ALLOYS



CANNON-MUSKEGON CORPORATION

2887 Lincoln Avenue • Muskegon, Michigan

METALLURGICAL SPECIALISTS

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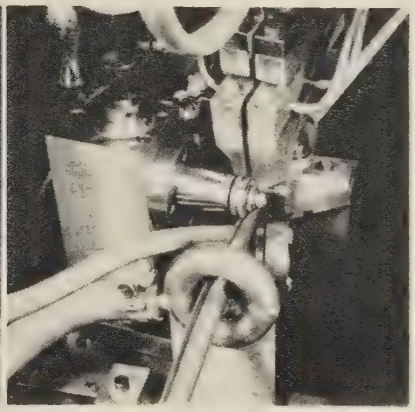


HIGH FREQUENCY WELDER

FINS, ribs, odd shapes and forms can all be welded to tubing and flat metals at high speeds with the Thermatool high frequency resistance welding technique developed and patented by New Rochelle Tool Corp., 320 Main St., New Rochelle, N.Y. The technique can be used to weld ferrous or nonferrous metals, including 100 per cent conductivity copper, and even metals like zirconium and titanium. Dissimilar metals, like copper and steel or high speed and carbon steel, can also be welded at speeds never before achieved, according to the company. One welding head can be used interchangeably with various metals and alloys for continuous welding of thicknesses from 0.004 to 0.375 in. at speeds up to 1000 fpm.

The technique of causing current to flow across a metallic joint to heat it to the melting point is not new. However, in the Thermatool method, the current reverses at the extremely high rate of 450,000 cps. At this frequency, the current follows the path of least inductance rather than that of least resistance. As a result, it produces a skin effect through localized and highly intense heating. This effect, says New Rochelle Tool, lends itself to lap- as well as butt-welding, and especially to mash-lap-welding.

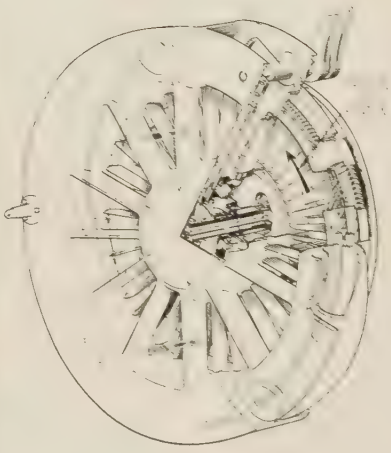
The welder can continuously weld flat strip, channel or inverted channel shapes to tubing; corners of square or rectangular tubing; I-beams and double I-beams that cannot be extruded or drawn; odd T-sections; longitudinal fins or ribs on tubing or strip; and tubes of different diameters. With material of finite length, you can weld a spiral fin on tubing, lips or edges to seal drum heads, perforated strip metal, and tubes joined by a spacer. Write in No. 65 on Reader Service Card for more information.

PANCAKE VTOL TURBOFAN

FOR powering VTOL aircraft, Boulton Paul Aircraft Ltd., Wolverhampton, England, has designed a turbofan that operates on air drawn straight from the compressor of the main thrust engine. Although air temperature may go up to 200 deg C, this design is called a "cold" gas drive. The entire assembly can be mounted inside an aircraft wing, with the rotational axis normal to the wing surface.

The Boulton Paul design consists essentially of a single-stage fan driven by a turbine mounted on the tips of the fan rotor blades. Air is fed from two supply pipes and expanded through turbine nozzles on opposite sides of the main housing. Its flow is controlled by cutouts in a throttle ring exposing and shutting off the nozzles. The ring is moved peripherally by a rack-and-pinion quadrant linked to an electric actuator.

Inlet guide vanes, which control the amount of "swirl" given to the air before it enters the rotor, operate in unison with the throttle ring.



Input power is actually varied with the work done by the fan.

In this manner, quick changes in thrust are obtained without changing the rotor speed. There is also no rotor inertia to introduce undesirable time lags.

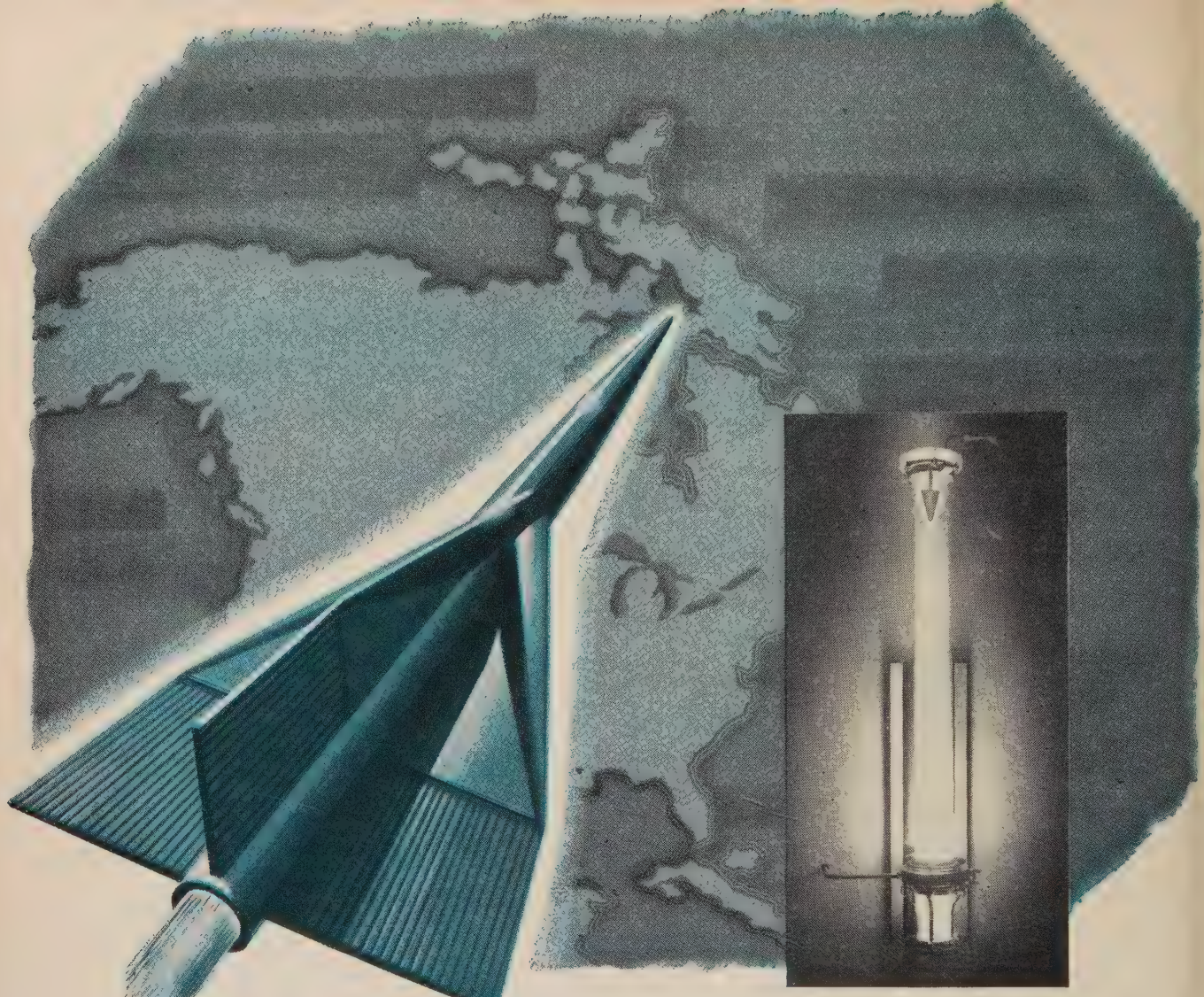
At a constant 6000 rpm, the 52-lb design can deliver an immediately variable thrust of ± 150 lb about a mean value of 550 lb. Write in No. 66 on Reader Service Card for more information.

CLEANING FACILITY

A CERTIFIED cleaning facility is available to aircraft and missile component manufacturers at Dunbar-Kapple, Inc., Batavia, Ill. The 1000-sq ft facility is enclosed in an air-tight, three-room complex that includes a dressing room, a cleaning room, and an inspection room. Air in the facility is changed 10 times an hour. Room pressure is held positive with respect to the outside to prevent the entry of foreign matter.

All cleaning fluids are double-filtered to ensure freedom from particles of over 10 microns. A high pressure, high speed spray is supplemented by simultaneous vacuum action in the turbulent spray area to prevent the redeposit of particles on clean surfaces.

After cleaning, parts are passed through a tunnel-type drying oven. The 25-ft-long oven is located between the cleaning and inspection rooms. An external vacuum supply discharges dirt directly to the outside. Write in No. 69 on Reader Service Card for more information.



Bendix electrically excited shock tube can be photographed by illumination from hot gases.

PLASMA PRODUCTION

. . . for magnetohydrodynamic investigations

Hypersonic flight can generate ionized shock layers with free electron densities as great as 10^{12} particles per cc. Temperature near the stagnation point can be as high as 7000°C. This is the self-generated environment of a missile or aircraft traveling at Mach 20 in the upper atmosphere.

To create these conditions in the laboratory for magnetohydrodynamic and electromagnetic propagation investigations requires a hypersonic wind tunnel. The Bendix electrically excited shock tube is such a research tool. Discharge of a capacitor bank into a conical region at one end of the tube instantly creates a shock wave which is driven down the length of the tunnel past the test body. Flow velocities up to 75,000 fps and temperatures of 20,000°C can be generated.

By passing electric and magnetic fields through the plasma in the shock tube, Bendix engineers can measure the attenuation of radio transmission through the ionized layer surrounding hypersonic vehicles. They can also investigate the acceleration of conducting gases for space propulsion, and the feasibility of direct conversion of thermal energy to electrical energy.

Plasma production is one of the projects being carried out at Bendix Systems Division to solve the technical problems which are the keys to the systems of the future. Other investigations include satellite communications systems, navigation satellites, advanced infrared reconnaissance, and the EAGLE Air-to-Air Missile System. Inquiries are invited from better engineers also looking to the future.

Bendix Systems Division
ANN ARBOR, MICHIGAN

Bendix
AVIATION CORPORATION

Write in No. 120 on Reader Service Card at start of Product Preview Section

TAPE SEARCH SYSTEM operates at 120 ips

Feature Product Award

FEBRUARY 1960

Electronic Engineering Co., 1601 E. Chestnut Ave., Santa Ana, Calif., has developed a tape search and control system that automatically plays back a selected portion of tape on an Ampex FR-100 unit. The system automatically searches either backward or forward to find a preselected time. At 120 ips, the searching required for 2500 ft of tape takes only four minutes. During the search, a continuous visual display of the tape time is produced by a 17-digit code register.

The system can be supplied to search any time code—e.g., the 17-bit one or the codes used at Patrick Air Force Base, Fla., or the Eglin (Fla.) test range. All-transistor construction is used throughout the system, which uses plug-in circuitry.

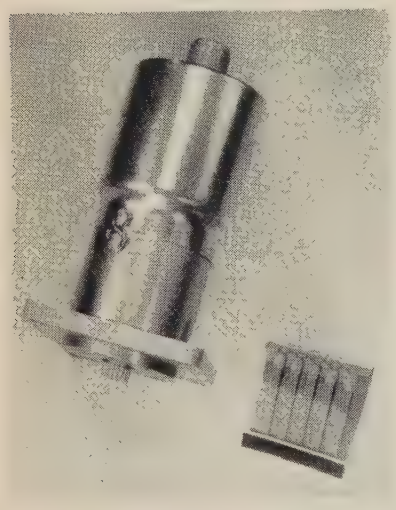
Write in No. 121 on Reader Service Card at start of Product Preview Section

This award is made in recognition of outstanding service performed through the development and manufacture of a product contributing to the advancement of the aerospace industry.

Randolph Hawthorne
Editor

product preview

SHUNT MOTOR has three connections



This reversible shunt motor has three lead connections, is available at speeds up to 25,000 rpm and torques up to 2000 ounce inches. It responds to varied torque loading through a wide temperature range, according to **Hydro-Aire Co., Dept. S/A, 3000 Winona Ave., Burbank, Calif.** Tests are said to have shown a change in morot speed, under varying loads, of less than one per cent through the temperature range from —65 deg F to 450 deg F.

Because of the three lead connections, the unit is said to offer infinite variations in motor characteristics such as highspeed/low torque or low speed/high torque.

Write in No. 260 on Reader Service Card

REGULATOR for extreme temperatures

This series HC-7300 pressure regulator meets performance requirements of MIL-R-5519 and offers adjustable speed control. It diverts the flow of a continuously operating pump to the reservoir during a "no work" period. Operating pressure range is 0 to 3500 psi, proof pressure is 5000 psi, and burst pressure is 9000 psi, says **Kemp Aero Products, Dept. S/A, Marshall Hill Rd., W. Milford, N.J.** Cut-in pressure ranges from 5 percent to 35 percent of cut-out pressure.

It provides a rate flow capacity of 10 gpm, but has been especially developed to meet AN pressure drop requirements up to approximately 20 gpm. It remains operable under extreme temperature conditions varying from —65 deg F to 275 deg F. It weighs .78 lbs.

Write in No. 261 on Reader Service Card

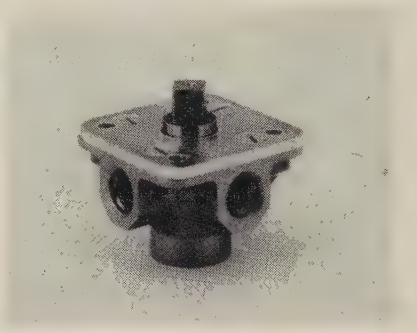
ACCELERATION SWITCH is highly versatile

This acceleration switch, designated As-13 series, has single-pole, double-throw, normally open contacts and can be furnished with a built-in relay to provide more complex switching contacts.

The design makes possible a wide range of dynamic performance characteristics, says **Humphrey, Inc., Dept. S/A, 2805 Canon St., San Diego, Calif.** It weighs less than four ounces.

Write in No. 262 on Reader Service Card

ROTARY VALVE has lap-fitted spool



This 3-way, 3-position manually operated rotary selector valve has a spool that is lap-fitted into a stainless steel forged body that serves also as the sleeve. This design eliminates more than half the number of packings usually required, thereby increasing reliability, according to **Hydra-Power Corp., Dept. S/A, Pine Court, New Rochelle, N.Y.** It is designated as Hp686100.

Integrating the sleeve and body also permits miniaturizing the unit.

Write in No. 263 on Reader Service Card

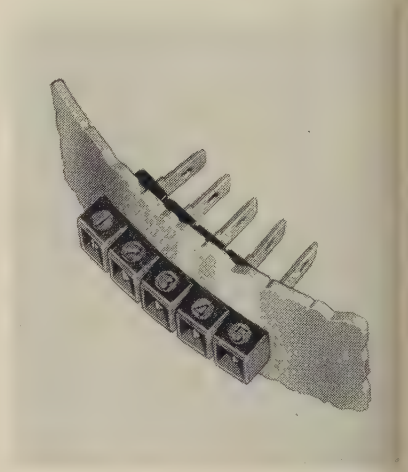
TRANSFORMER is subminiature

This sub-miniature coaxial ratio transformer measures 2½ in in diameter, is qualified to MIL specs, and is said to be accurate to 0.01 per cent. It is designed for severe environments. This ac voltage divider has inherent characteristics of high input impedance, low effective output impedance, and very low phase shift, says **Gertsch Products, Inc., Dept. S/A, 3211 So. La Cienega Blvd., Los Angeles 16, Calif.**

It has an input voltage of 0.35 f or 140-v max at 400 cps. It operates over a frequency range of 50 to 10,000 cps. It has a shock resistance of 50 g's for 7 milliseconds.

Write in No. 264 on Reader Service Card

BUSHINGS are accordion type



This junction terminal bushing, which snaps into curved and flat surfaces, is miniature accordion type nylon insulated receptacles which mates with 3/16 and ¼ in standard disconnect terminals. Available as single or as flexibly connected groups up to five and are number coded. Available for color coding, according to **Heyman Mfg. Co., Dept. S/A, 1200 Michigan Ave., Kenilworth, N.J.**

They are used for electrical circuits and components, such as motors and control devices, by eliminating "pig tail" wire leads, screw terminals and junction blocks.

Write in No. 265 on Reader Service Card

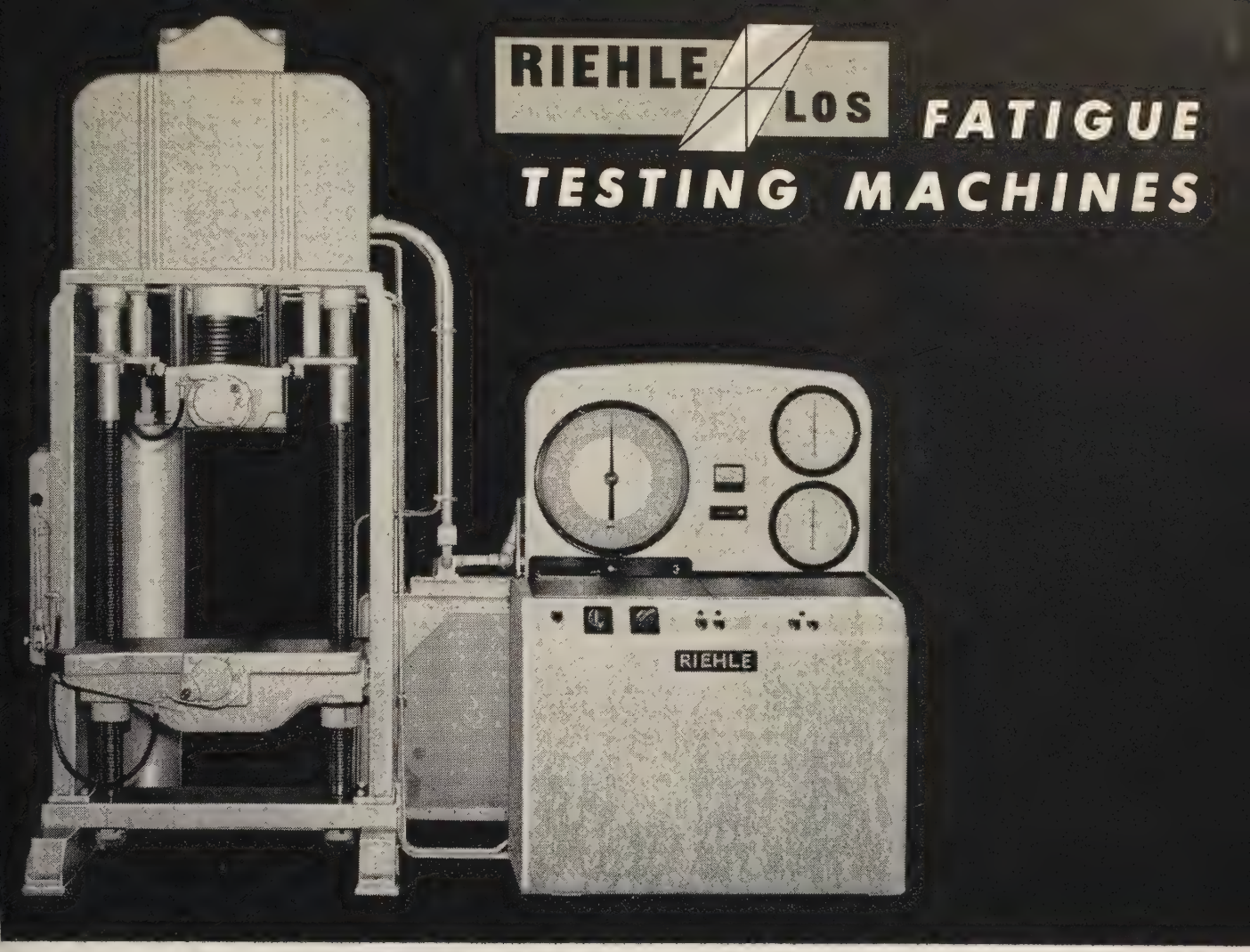
PRESSURE TEST SET is portable

This portable vacuum-pressure test set is designed to test and calibrate air data aircraft instruments, computers and pitot static systems. Overall dimensions of the VPT-10B are 8½x 15x20 in, including the carrying case. Weight is 45 lbs, according to **Intercontinental Dynamics Corp., Dept. S/A, 170 Coolidge Ave., Englewood, N.J.** The instrument complement consists of a Kollsman altimeter with a range of —1000 to —80,000 ft and a Kollsman airspeed indicator with a range of 60 to 650 knots.

Static pressure range is —1000 to 45,000 ft. Pitot pressure range is 60 to 450 knots. Static and pitot regulation accuracy is ±.003 in Hg. plus 0.00015 in Hg. per degree centigrade change in temperature over the entire range. Instrument accuracies are in order of ±20 ft and ±1 knot when calibration cards are used.

Write in No. 266 on Reader Service Card

more on page 193



RIEHLE-LOS FATIGUE TESTING MACHINES

rst to combine static and dynamic testing capabilities

eaturing a basic system of compatible components, new ILE-LOS Hydraulically-Actuated Fatigue Testing Machines nit far greater variety and versatility in testing pro- ns than is possible with any other machine. Available in els with capacities ranging from 12,000 to 300,000 ids, new RIEHLE-LOS machines can be used to perform umic tests as well as conventional static tests.

sing the basic system of console, pulsator and loading both alternating and fluctuating loadings on test spe- ns can be applied. Infinitely variable frequencies be- n 125 and 1000 c.p.m. can be obtained while the nine is being operated by the pulsator. A slow-cycle ol accessory can be connected to provide frequencies about 5 to 100 c.p.m.

including RIEHLE recording and strain measuring instrumentation in the system, conventional static testing can be performed on the new machines. Tension and compression tests are done in the same space, so transition from one to the other is easily accomplished.

Other accessories which can be integrated to extend the utility of the machines include a programmer to automatically vary load levels and frequency and General Purpose Testing Cylinders for testing large parts and assemblies.

Installation is simplified because new RIEHLE-LOS Fatigue Testing Machines are floor models, requiring no pit.

OTHER RIEHLE TESTING MACHINES: Hydraulic and Screw Power Universal Testing Machines, Construction Materials, Impact, Brinell, Torsion, Horizontal Chain, Rope and Cable Testing Machines, Portable Hardness Testers for Rockwell Readings, etc.

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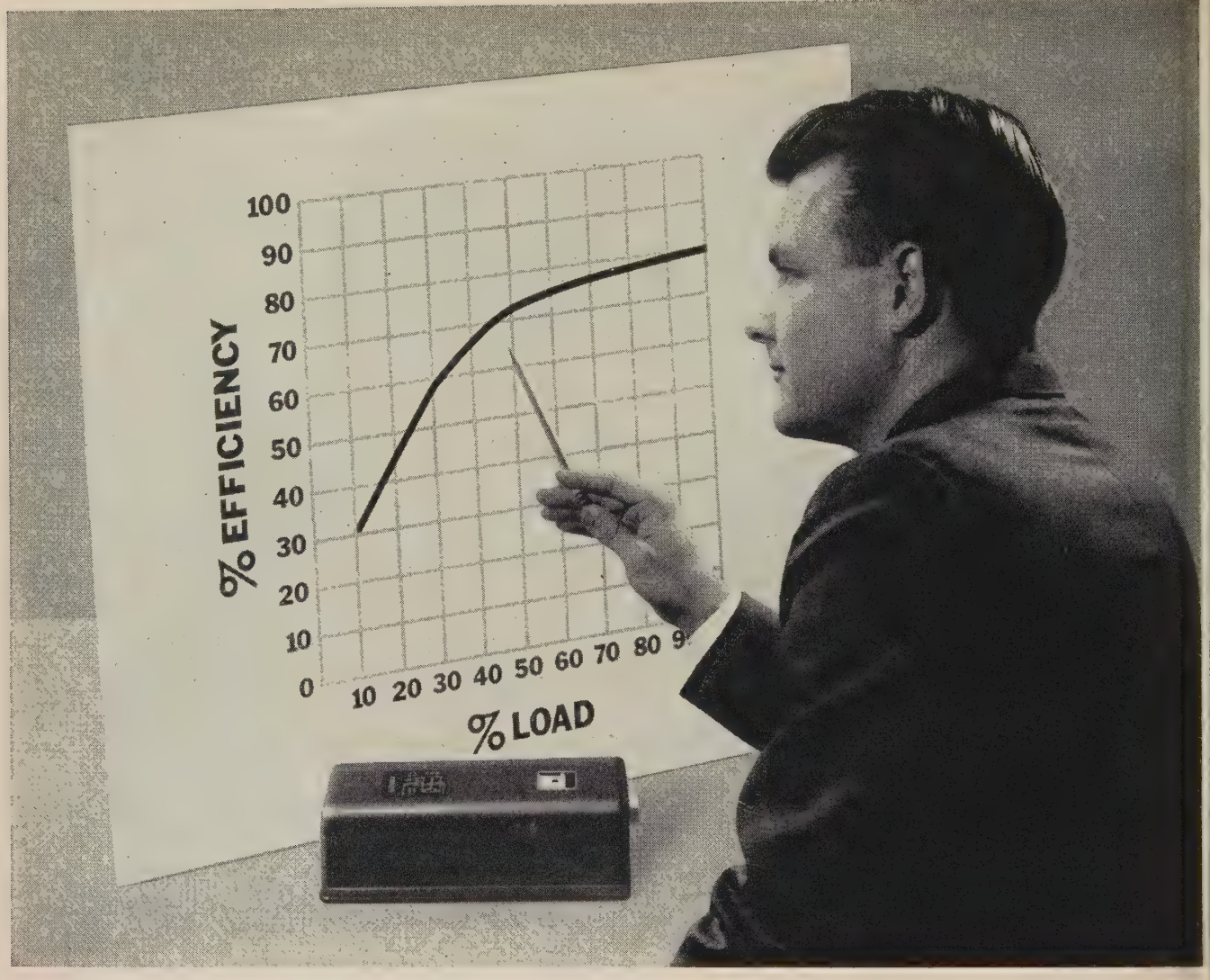
Please send me Bulletin RF-10-59 on the new RIEHLE-LOS Fatigue Testing Machines.

NAME _____

COMPANY _____

ADDRESS _____



Over 70% efficiency at only half load with the Kinetics Static Inverter

Close frequency control and accurate phase displacement is obtained with crystal-controlled digital countdown circuitry.

The nearest approach yet to a flat efficiency curve for a static inverter is achieved by a new Kinetics design. Even at a fraction of full load, good efficiency is obtained. The Kinetics unit is ideal for aircraft and missile applications in the range from 15 VA to 15 KVA per phase.

There are no moving parts, no vacuum tubes and no transistors in high current circuits in the Kinetics inverter. The design features rugged silicon semi-conductor elements that are able to carry heavy current without failure. A common complaint about transistorized inverters is that they must incorporate cutoff devices in order to protect extremely sensitive power circuits from short circuits or high voltage transients. The silicon diodes will carry extremely heavy overloads, including shorts, for several seconds. This is usually long enough to trip the circuit breaker in the circuit carrying the short.

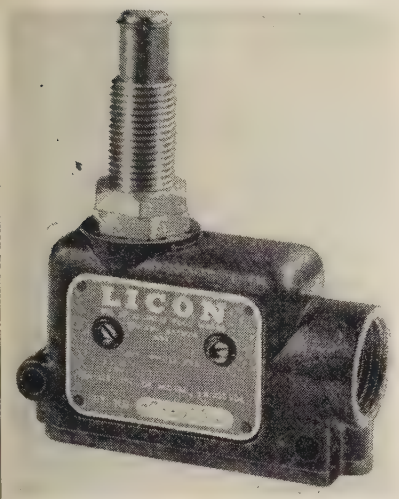
The Kinetics design offers low-loss regulation and the output is very nearly a perfect sine wave. A high degree of reliability is achieved by the use of extremely rugged components and the lack of complex circuitry. The Kinetics inverter is relatively unaffected by severe environmental conditions. Write or phone for more information. Kinetics Corporation, Dept. K-16, 410 South Cedros Avenue, Solana Beach, Calif. SKyline 5-1181.

KINETICS
CORPORATION

ELECTRONICS • ELECTROMECHANICS

Write in No. 123 on Reader Service Card at start of Product Preview Section

IMPULSE SWITCH has one-way design



Simplified electrical control for solenoid valves and starter relays through the elimination of one-way actuators, interlocks or delay devices is provided by this one-way impulse switch, says **Illinois Tool Works, Dept. S/A, 2501 N. Keeler Ave., Chicago 39, Ill.** The Licon unit is reported to be particularly useful for air cylinder and hydraulic applications.

Over five million activations can be achieved by the 15-amp switch, all moving parts of which are made of hardened stainless steel. Other features include a choice of mounting methods, generous wiring space, and a standard conduit receptacle.

Write in No. 267 on Reader Service Card

MECHANICAL COUNTER is very precise

The Series 200 mechanical counter is a highly precise instrument designed for temperature, pressure, position distance and time indication use in ground support equipment, telemetering, fire control and other computers required in exacting military, airborne navigational, automation and other applications. The counter has operating speeds up to 1350 rpm and built-in stopping points, and it can be supplied for use with servo-operated readin and readout, according to **Chicago Dynamic Industries Inc., Dept. S/A, 1725 Diversity Parkway, Chicago 14, Ill.**

Two to ten wheels of machined aluminum can be supplied with engraved figures white on black or black on white, and the counters operate in both directions from zero. The corrosion and fungus resistant device withstands vibration along each principal axis through a total excursion of 0.06 in for one hr at ten to 55 cps.

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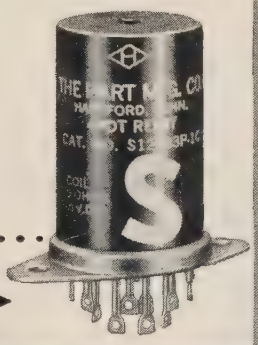
more on page 195

BUILT BY MARTIN

FOUR OPERATIONAL MISSILES

Heart of the Control System . . .



"DIAMOND H" RELAYS

Hart relays are of three basic types: miniature, hermetically sealed, aircraft-missile relays (Series R/S); high speed, sensitive, polarized relays (Series P), and general purpose AC, DC relays (Series W).

Technical literature outlining the wide range of characteristics available with each type relay is yours for the asking. You'll find "Diamond H" engineers uncommonly adept at working out a variation of the basic designs to meet your set of specific requirements.

Tell us your needs . . . by phone, wire or letter.

THE **HART** MANUFACTURING COMPANY
212 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

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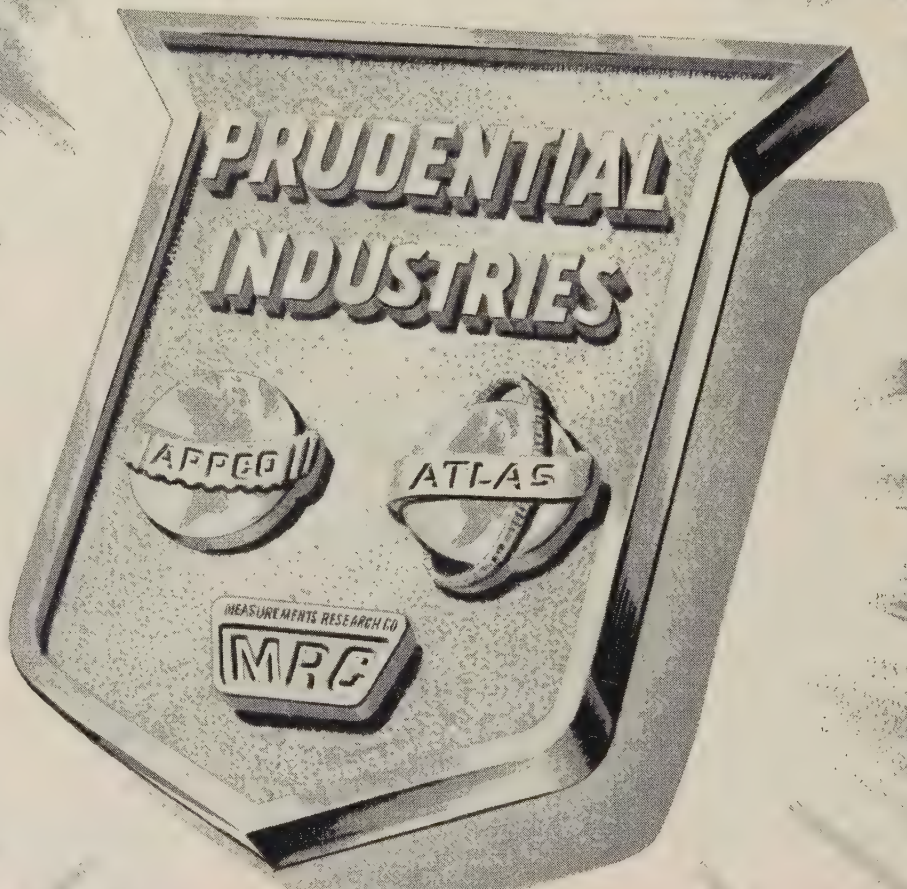
Symbol of Progress
In the World of Precision



ATLAS PRECISION PRODUCTS CO.

Specialists in the design and production of electro-mechanical assemblies and fine precision gears, differentials and components for use in computer, automation and guidance systems of industry and the Armed Services. Precision gears are Certified to meet A.G.M.A. specifications and stocked in pitches from 32 to 120. APPCO components are now in use in the nation's finest precision mechanisms.

MEASUREMENTS RESEARCH CO.

Designers, developers and producers of custom electronic test equipment for quality control, production test inspection and high reliability. Pioneers of new approaches and economical solutions to the testing and evaluation of manufactured items through application of electronic techniques. Fully staffed for research and development work, equipped for complete production of electronic and electro-mechanical units of all types.

ATLAS CHAIN & MANUFACTURING CO.

Wholly owned subsidiary producing power transmission products for all types of industries. Atlas Roller Chain, Flat-Veyor conveying chain, specialty chains, sprockets and flexible couplings have proved their outstanding performance value in every type of industry where power or motion is to be transmitted. Atlas Chain has pioneered many new innovations in the power transmission field and many new developments are now in the final test stage in their extensive research laboratories.

Let Prudential Industries add extra precision to your products, write for complete details to Castor and Kensington Aves., Philadelphia 24, Pa.

PRUDENTIAL INDUSTRIES

Precision-eers For Industry

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TUNED SIGNAL SOURCE covers high frequency range

Model 301 Remote Tuned Signal Source is ideal for antenna test applications where the source must be located at great distances from the receiving site, says **Scientific-Atlanta Inc., Dept. S/A, 2162 Piedmont Rd. N.E., Atlanta 9,, Ga.**

The weatherproof Carcinatron RF Heads cover the frequency range from 100 to 16,000 mcps. The power output varies from 500 mw to 5 mw over this frequency range.

Write in No. 269 on Reader Service Card

VIDICON TUBE is highly sensitive

The WL-7325 vidicon tube is capable of resolving detail information equivalent to 600 television lines, says **Westinghouse Electric Corp., Dept. S/A, Box 2278, Pittsburgh, Pa.** The tube can produce satisfactory pictures from scenes with a wide range of illumination levels, and with average illumination down to 0.1 ft-c.

Improved uniformity is reported to be the result of new techniques in the preparation of target layers. A gain of about two times in signal current is thus obtained without limitation due to edge flare and other major nonuniformities.

Write in No. 270 on Reader Service Card

SENSOR ASSEMBLIES are very stable

Temperature changes of under 0.001 deg F can be detected by these temperature sensor assemblies, **says Victory Engineering Corp., Dept. S/A, 554 Springfield Rd., Union, N.J.** The devices include thermistors that are reliable and highly stable.

The assemblies, which may be mounted by a variety of techniques, are useful for in-flight telemetering of surface, liquid, gas and air temperature data for missiles, satellites, and conventional aircraft. Other applications include control of chemical processes, liquid levels, and air conditioning equipment. The units are housed in stainless steel, aluminum, brass, or plastic.

Write in No. 271 on Reader Service Card

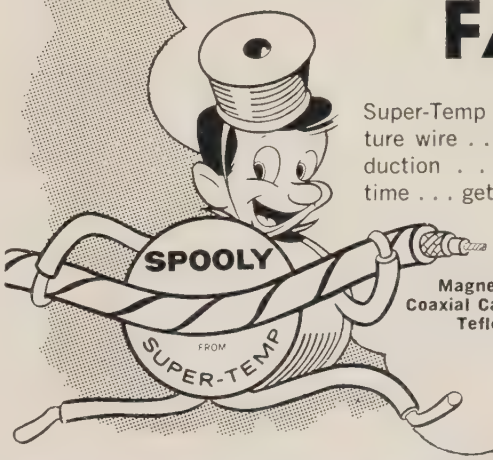
more on page 197

BUILT BY MARTIN

ONLY OPERATIONAL NAVY AIR-TO-SURFACE GUIDED MISSILE

"SPOOLY" SAYS...

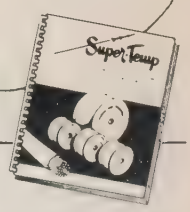
SUPER-TEMP DELIVERS WIRE FASTER!



Super-Temp has **everything** in high temperature wire . . . complete line . . . fastest production . . . **quickest delivery.** Don't lose time . . . get one stop service at Super-Temp.

Magnet Wire, Airframe Wire, Hook-up Wire Coaxial Cables, Miniature & Jumbo Cables, Tapes Teflon* or Silicone Rubber Insulations

*DUPONT'S TFE RESIN



Save Time WITH Super-Temp

American Super-Temperature Wires, Inc.

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General Sales Office: 195 Nassau St., Princeton, N. J. • WAlnut 4-4450

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Free! Send for 1960 Catalog. 88 pages of valuable data.

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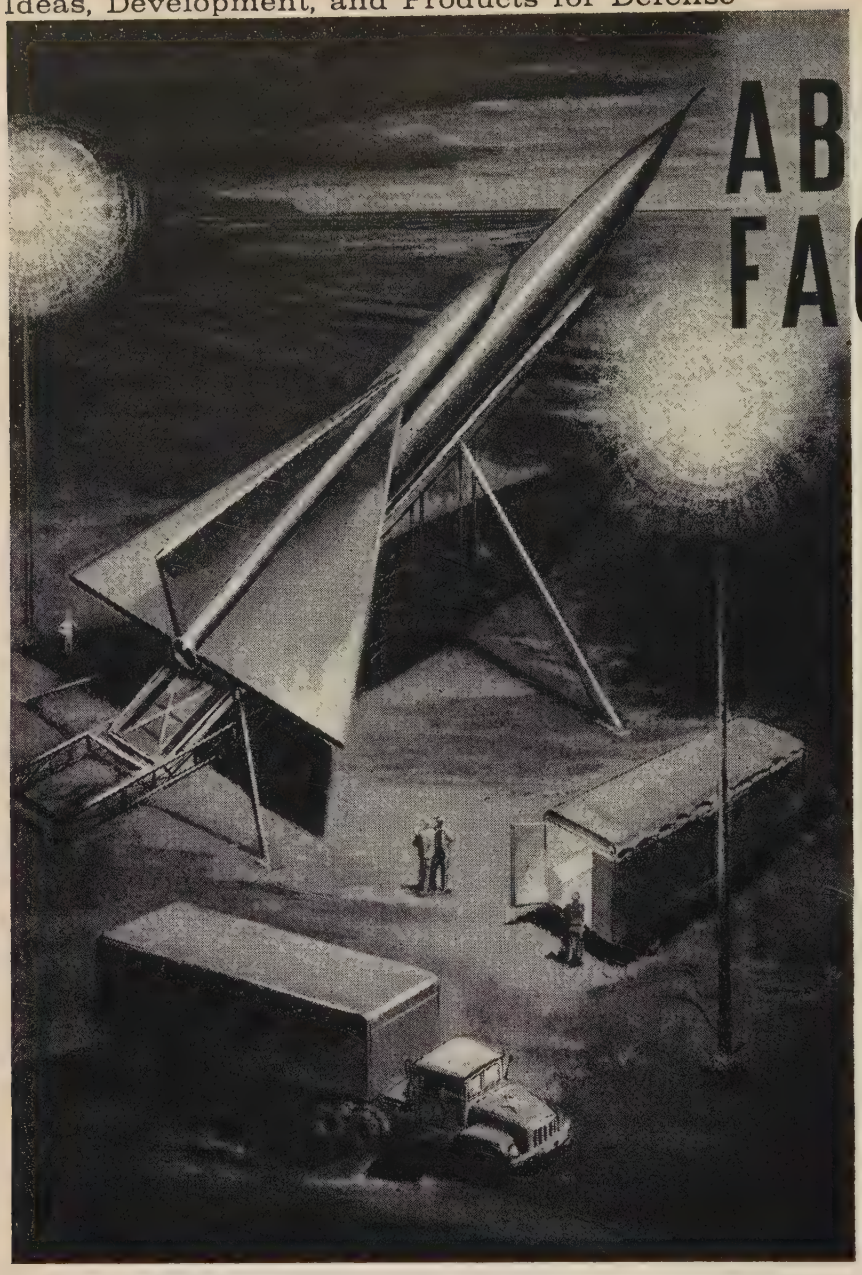


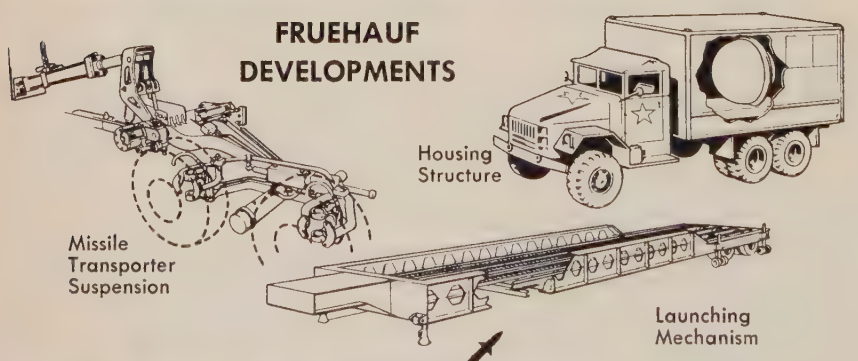
ABILITY AND FACILITIES

Fruehauf has the people, experience, and plants to engineer or produce any type of mobile housing, handling, launching, or maintenance unit or system!

Among the organizations best qualified to conceive, develop, and produce units or complete systems for weapons or material handling are the two military divisions of Fruehauf Trailer Company. Few, if any, American firms have a broader background of detailed work on such a great variety of contracts.

Fruehauf engineers have already made major design contributions to the transporting and launching systems of numerous missile types . . . to shelters and housing for numerous guidance systems . . . and to other, widely diversified military projects. No handling problem is too large, no need too small, for the extensive Fruehauf staff of highly trained military specialists and the Fruehauf network of strategically located manufacturing plants.

Phone or wire for a Fruehauf representative to give you complete details, or write for fast facts on available facilities.



FRUEHAUF TRAILER COMPANY

Plants in the East and West

MILITARY EQUIPMENT DIVISION — DETROIT 32, MICH.

MISSILE PRODUCTS DIVISION — LOS ANGELES 58, CALIF.

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AC POTENTIOMETER cuts loading error

The Vernistat Model 3B, a precision ac potentiometer with a linearity of ±0.01 per cent, substantially eliminates loading error problems because of its 40-ohm output impedance. It is suitable for use as a component in inertial guidance, navigation, fire control and other analog systems, says **Perkin-Elmer Corp., Dept. S/A, Norwalk, Conn.**

The device is based on use of a wire-wound potentiometer and a precisely tapped autotransformer, a combination of devices which often permits elimination of isolation amplifiers and other system components. Another result of the combination is an appreciable reduction of noise problems in analog applications. At 400 cps, quadrature is under 0.1 mv/v, minimum input impedance is 50,000 ohms, and maximum input voltage, 35 V. The Model 3B offers continuous mechanical rotation to simplify design problems.

Write in No. 272 on Reader Service Card

FREQUENCY CONVERTER driven at 1200 rpm

This housed frequency converting system is a 1200 rpm synchronous motor driven unit and contains all necessary switch-gear and regulating equipment for both motor and generator, says **Kato Engineering Co., Dept. S/A, Mankato, Minn.** The motor and generator are mounted on a single shaft within a common frame with the motor exciter of the sleeve type and mounted on an extension of the main drive shaft.

The generator output is 40 kw, 50 kva, .8pf, 120/208 v, 3 phase, 6 wire, 400 cyc, 40 pole, 1200 rpm, revolving field type with static excitation, power to the rectifying unit being supplied from the motor input source. The generator is powered by a 440 v, 80 hp, 3 phase, 6 pole, 60 cyc, 1200 rpm synchronous motor with rotating exciter.

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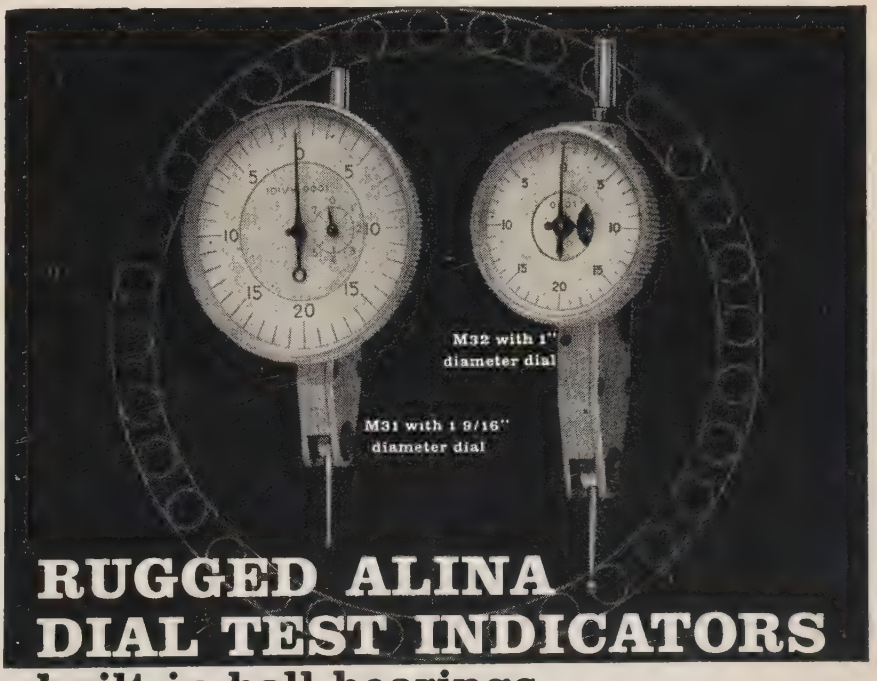
more on page 199

BUILT BY MARTIN

FIRST FULLY OPERATIONAL ELECTRONIC AIR-DEFENSE SYSTEM



RUGGED ALINA DIAL TEST INDICATORS

built-in ball bearings

for greater sensitivity—reduced pressure—improved accuracy

- Jeweled • Shock Proof • Range .032" • Graduated .0001"
- Reading 0-20-0 • Fully reversible contact point

Available with a wide variety of rectangular or round shanks.

The instruments shown here are part of a complete line of precision DIAL TEST INDICATORS of all types — Write for brochure!

ALINA CORPORATION

122 East Second St., Mineola, L.I., N.Y.

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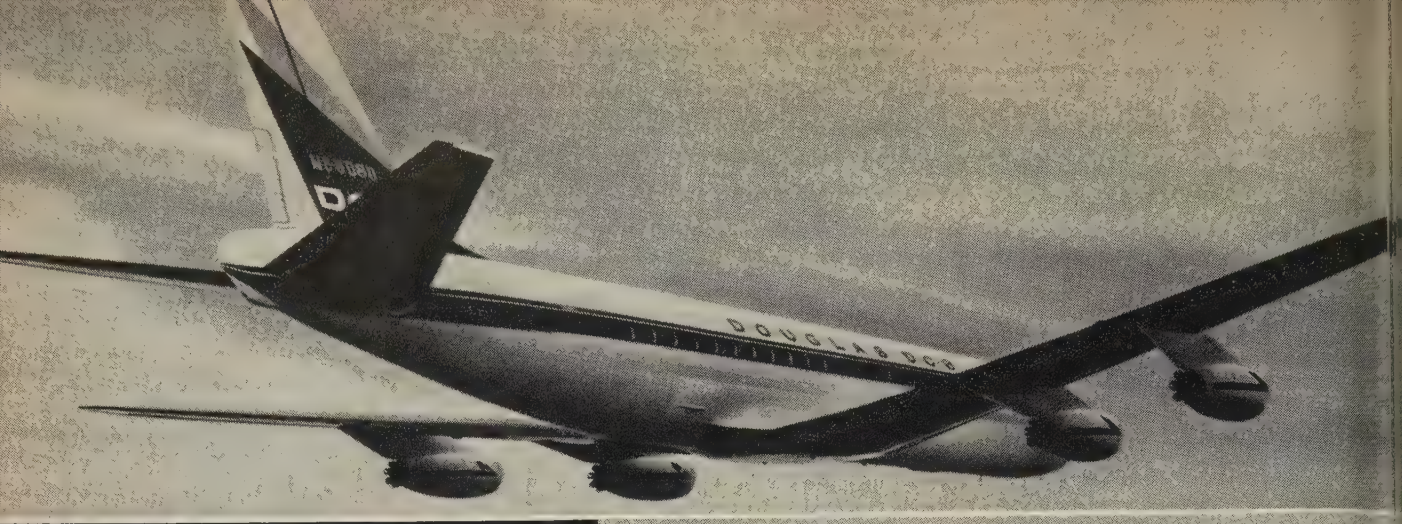
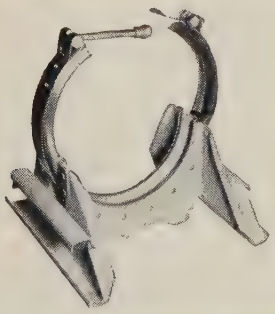
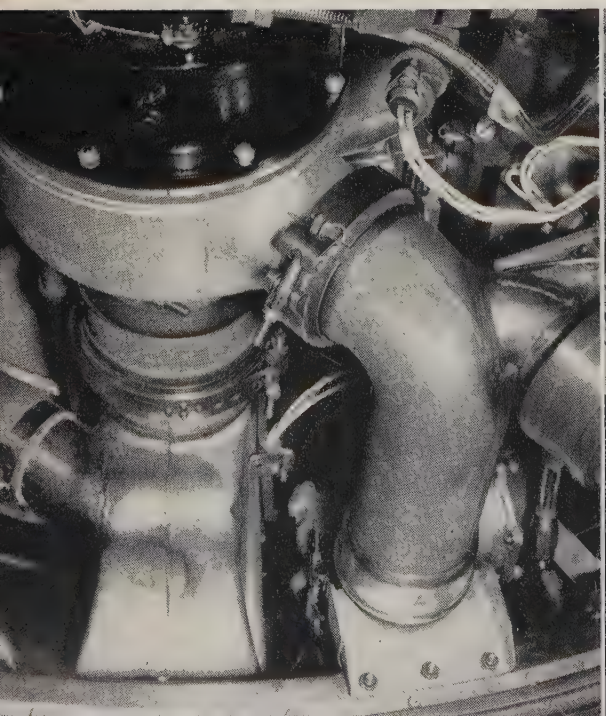
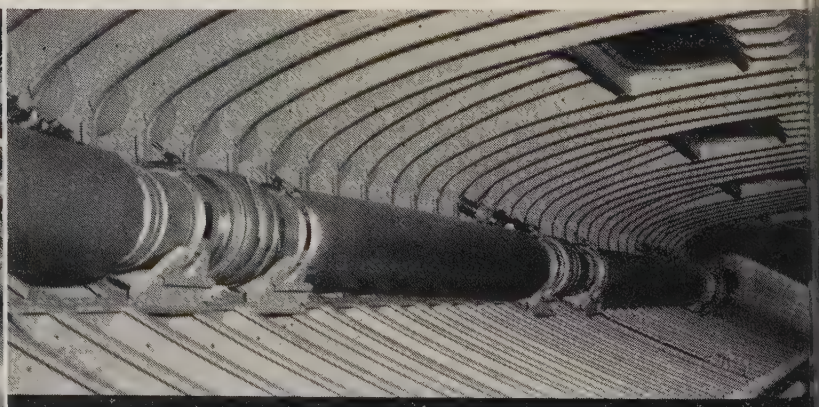


performance proved



Step aboard United Air Line's new Douglas DC-8 Jet Mainliners with complete confidence that every component has been performance proved. Inside the mighty structures are scores of Janitrol couplings linking vital high pressure air ducts. Only top quality products are used in the DC-8's. Write for the comprehensive booklet, "Janitrol Resources," which documents the capabilities and facilities behind Janitrol quality products. Janitrol Aircraft, a division of Midland-Ross Corporation, 4200 Surface Road, Columbus 4, Ohio.





JANITROL

pneumatic controls • duct couplings and supports • heat exchangers
combustion equipment for aircraft, missiles, ground support

THERMOCOUPLE WIRE for high temperatures

These insulated, metal sheathed thermocouple wires, designed to withstand ambient temperatures of 2000 deg F plus, are used where high temperatures must be accurately measured and where thermocouple leads must pass through zones of extreme heat, says **Revere Corp. of America, Dept. S/A, Wallingford, Conn.** Insulation is selected crystalline magnesium oxide compacted to maximum density inside the sheath.

Sheaths are said to be impervious to moisture, oils, petroleums, ozone, and solvents, and are immune to age deterioration.

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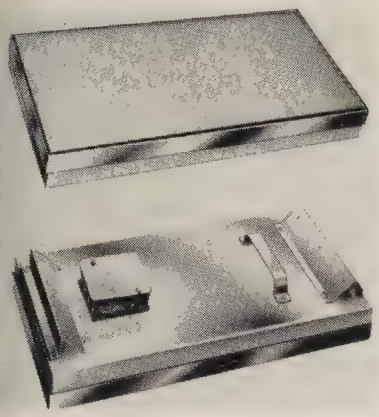
INFRA-RED ELEMENT uses slab-faced quartz



These slab-faced quartz elements are unidirectional, direct source—no reflectors, long wave-length, non-color selective, compact and rugged—offering unlimited design and application possibility, says **Ampere Industries, Dept. S/A, 60 Boston St., Newark 3, N.Y.**

The unusual design creates a new high in infra-red emissivity efficiency and long life. In addition flexibility of application is practically unlimited.

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LIGHTWEIGHT MOTOR is highly efficient

This 28v dc light weight motor has square frame for operation on dc power sources and delivers 3.8 hp at 200 rpm, continuous duty. It is said to be 82 per cent efficient at 3.0 hp and 80 per cent at 3.8 hp, according to the **Hoover Electric Co., Dept. S/A, Hangar Two, Port Columbus Airport, Columbus 19, Ohio.** Radio noise filter to MIL-I-6181B.

It is 9.250 in long, 5 in in diameter and weighs 14.4 lbs. It is designated Model D-2370.

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more on page 201

BUILT BY MARTIN

FIRST AIR FORCE OPERATIONAL GUIDED MISSILE

SCHULER

Enlarged research and development of precision mechanisms used in Inertial Guidance have enlarged our staff openings for engineers, scientists and mathematicians with 3 to 5 years of experience in this field. Write to Mr. C. T. Petrie, Manager, Research & Engineering Staff.

LITTON INDUSTRIES Electronic Equipments Division
Beverly Hills, California

zero plus

. . . and Carlson special stainless steels withstand the extremes of another launching

WHEN this missile "lifts off," Carlson special stainless steel plates help launch it into space. These plates are the high strength, precipitation-hardening grades. And there are sound reasons why these grades are used.

First, with Armco 17-4PH, 17-7PH and PH15-7 Mo* it is easier to attain the high physical properties and resistance to elevated temperatures required in space flight engineering. Simplified low temperature heat treatment will develop a Rockwell hardness of C40 to C50. Tensile strengths, so vital in missile components, range from 180,000 to 220,000 psi in plates.

Second, only Carlson produces these Armco grades in the heavier plate thicknesses. For applications where high strength at high temperatures and ease of fabrication are important, get plates in these grades from Carlson. We will be glad to work with you on specific applications.

*17-4PH, 17-7PH and PH15-7 Mo are trade marks of Armco Steel Corporation

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PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES
FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)

Photo of Atlas missile courtesy
CONVAIR ASTRONAUTICS,
A Division of General Dynamics Corp.

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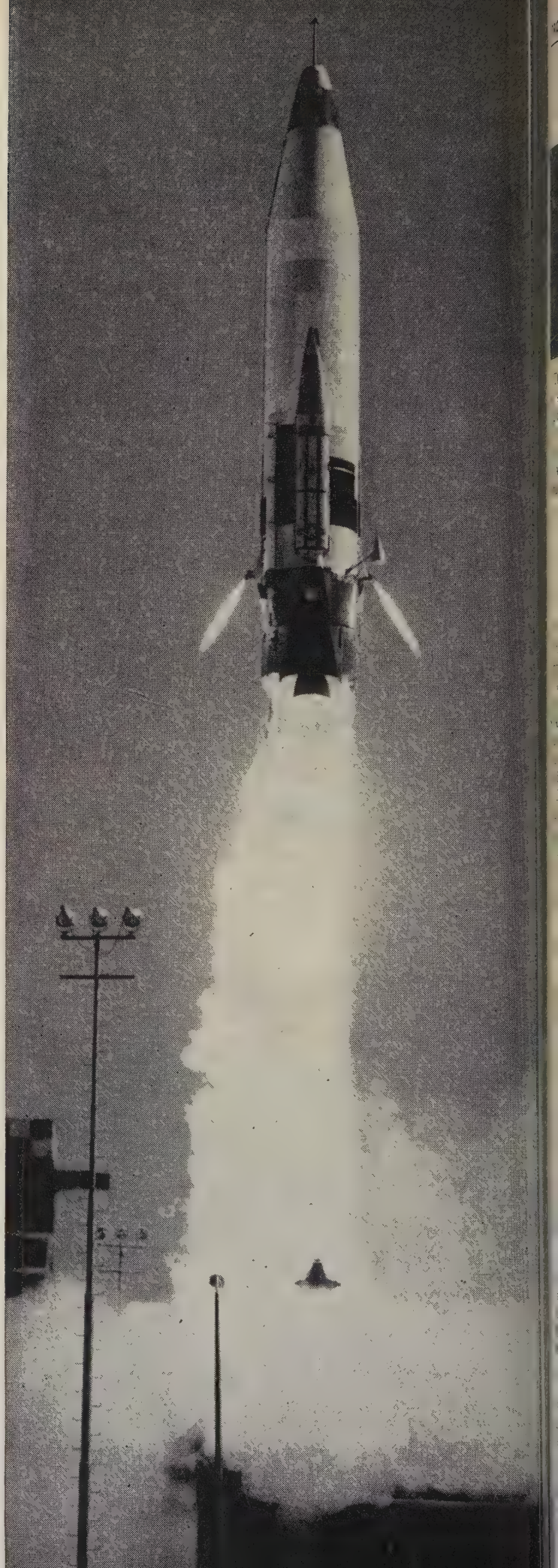
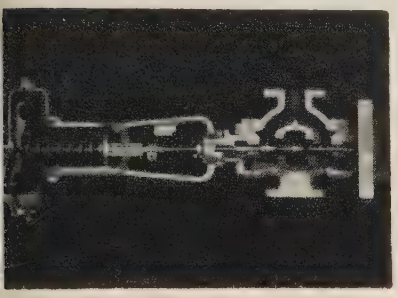


FUEL LOADING VALVE for steam, gas, liquids



This high volume control valve is for steam, gases, liquids and pressure regulators. It is part of an installation for a new liquid fueled missile facility slated for 1960 completion, according to **A. W. Cash Co., Dept. S/A, Decatur, Ill.**

Write in No. 277 on Reader Service Card

PRESSURE SWITCH highly sensitive

This piston type differential pressure switch for hydraulic systems will sense a pressure difference of 10 to 2000 psi in an operating system of 50 to 5000 psi, says **Fisher Controls, Inc., Dept. S/A, 1928 Lincoln Blvd., Santa Monica, Calif.** It is suitable for use in sensing the pressure drop through an orifice filter, etc.

These valves weigh about 4 oz., are 3½ in long and have an operating temperature of −65 to 160° F. and an electrical rating of 15 amps at 120 v ac.

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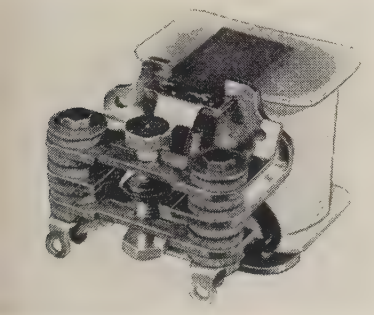
MIDGET RELAY has self-wiping contacts



This series 51C midget relay, having self-wiping contacts, is for dc operation only. It has adjustable 2 amp DPDT screw contacts, says **Kurman Electric Co., Dept. S/A, 191 Newel St., Brooklyn 22, N. Y.** Rigid front mile up.

Variations, including 5 amp contacts, H. S. military relays, coils to 50,000 ohms available. Mounting: No. 6-32 tapped holes on 0.437 centers.

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BUILT BY MARTIN

ARMY'S MOST ACCURATE SURFACE-TO-SURFACE MISSILE

Joclin announces...

FLUOROBOND

MAKES TEFLON AND KEL F† BONDABLE TO METAL, GLASS, FABRIC, ITSELF, ETC.*

Properties . . .

1. Easily applied by dipping, spraying, brushing *in your own plant.*
2. 15 seconds — maximum for treatment. No waiting, no delays.
3. No detrimental effect on electrical properties of the fluorocarbon material processed.

*Trademark DuPont
†Trademark 3M Company

Available in pint and quart cans; in gallon and five gallon containers.

The Joclin manufacturing company
22 Lufbery Avenue
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ON MARK COUPLINGS

NEW ON MARK FLEXIBLE LINE COUPLINGS ON THE DC-8

Standard equipment on the Douglas DC-8 fuel lines is ON MARK's new Flexible Fluid Line Couplings. Vastly superior to old style "AN" tube unions, this new coupling has been tested far beyond the requirements of specification MIL-C-25014 with simultaneous flexure, axial motion and pressure cycling at −65°F. WITH NO DEVIATION. Simpler in design, easy to assemble (NO SPECIAL TOOLS NEEDED), and lighter, the ON MARK coupling seals on deformed, marred and scratched tubing at all temperatures. Tests prove these couplings to be equally effective for special requirements such as hot air, gases, exotic fuels, and vacuum.

***In production* in standard tubing sizes.**

For full information please contact

ON MARK COUPLINGS, INC.

4440 York Boulevard, Los Angeles 41, California

Telephone CLinton 4-2278

Representatives Airsupply-Aero Engineering Division of the Garrett Corporation with district offices in Beverly Hills, Calif.; Mineola, N. Y.; Indianapolis, Ind. The Garrett Corporation of Canada, Ltd., Montreal, Canada.

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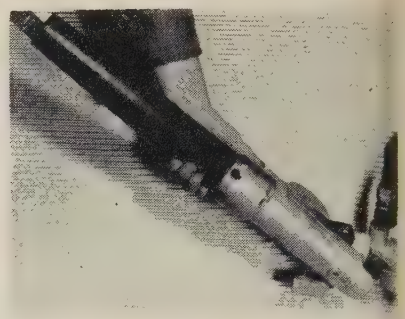
HOSE CONNECTOR is safe and speedy



This quick hose connector is for high pressure air or liquid and is being used with compressed air to start aircraft jet engines. The hose is always charged. The operator inserts the connector probe into the airplane receptacle. As the engine starts the operator disengages with a tug on the hose, according to **Besler Corp., Dept. S/A, 4053 Harlan St., Emeryville, Oakland 8, Calif.**

It handles pressures up to 4000 psi. Burst pressure is about 20,000 psi minimum. A fast flow of air is available: through the ⅝ in hose with 3,000 psi inlet and discharge into atmosphere 650 lb of standard air per min will flow, or 7,500 scfm.

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GROW WITH AIRESEARCH IN ELECTRONICS

AiResearch expansion in electronics and electromechanical activity is creating outstanding positions at all levels for qualified engineers.

AIRBORNE INSTRUMENTATION ANALYSIS AND DESIGN

Work involves solving problems in accuracy, response and environmental effects.

Openings also exist in the following areas: Flight Systems Research . . . Controls Analysis . . . Data Systems Research . . . Electromagnetic Development . . . Flight Data Components . . . Instrument Design.

Send resume to: Mr. Robert Richardson

THE GARRETT CORPORATION

AiResearch Manufacturing Division

9851 So. Sepulveda Blvd., Los Angeles 45, Calif.

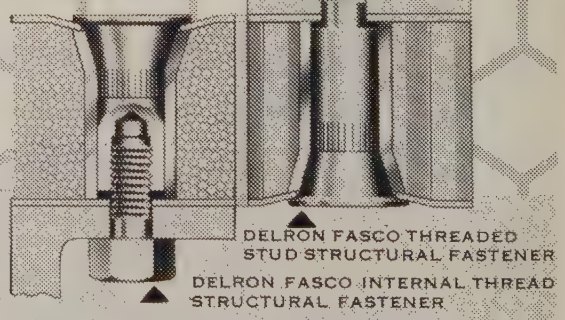
Check Employment Inquiry Form on Page 161

HONEYCOMB and sandwich panel FASCO FASTENERS

by Delron

PATENT PENDING

AIRCRAFT, MISSILE AND ELECTRONIC INDUSTRIES!



DELRON FASCO THREADED STUD STRUCTURAL FASTENER

DELRON FASCO INTERNAL THREAD STRUCTURAL FASTENER

Illustrated above are two of the many new Delron structural design fasteners now available for Honeycomb and Sandwich Panels.

• Write for engineering data.

. . . Largest manufacturer of specialized Sandwich Panel Fasteners.

THE DELRON COMPANY, INC.

5224 Southern Avenue, South Gate, California

LOrain 7-2477

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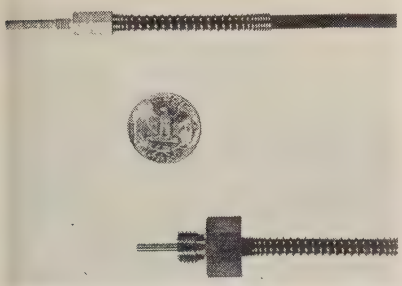
SOLENOID VALVE for pilot control

This valve, direct operating three-way, two-position solenoid with short response time can also be used to provide pilo tcontrol for larger valves To activate, the solenoid requires 1 amp max at from 14 to 30 VDC when handling pressures to 1000 psi. It will handle fuels, oils, air, and other gases. In ⅜ in. line size this control weighs .89 lb. Operating temperature range is —65 deg F. to +350 deg F., fluid or ambient, says **Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa.** Pressure drop is 0.12 psi at 200 lb/hr fuel flow.

Known as Part No. 30-1988-000, the valve is adaptable for operating temperatures to 500 deg F. and for higher pressures.

Write in No. 281 on Reader Service Card

MINIATURE TRANSDUCER has wide temperature range



This tungsten resistance thermometer, having probe weight, less connector, of 2 ozs, is said to be highly accurate and with wide temperature ranges, —450 deg F to +2000 deg F, according to **Astra Technical Instrument Corp., Dept. S/A, 1132 Mission St., S. Pasadena, Calif.**

Transducer features body rotation and withstands high vibration and shock.

Write in No. 282 on Reader Service Card

VOLTAGE INDICATOR can be programed

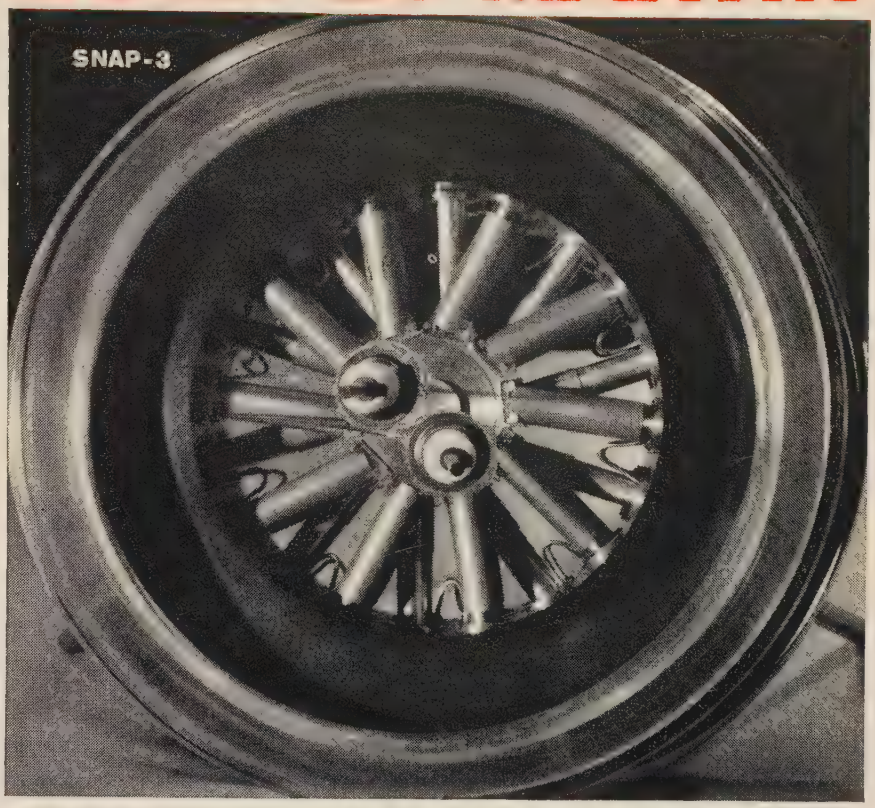
This voltage indicator has an accuracy of 0.1 per cent on d-c units and 0.25 per cent on a-c units, and can be programed either manually or automatically by an addition of external resistors, says **Voltra Products, 1010 Mission St., So. Pasadena, Calif.**

Sensitivity of the indicator is 1000 ohms per volt. The Ac indicator maintains its accuracy over a frequency range of 50 to 5000 cps. Temperature compensated indicators are available covering a range of —55 deg C to +71 deg.

Write in No. 283 on Reader Service Card

more on next page

BUILT BY MARTIN

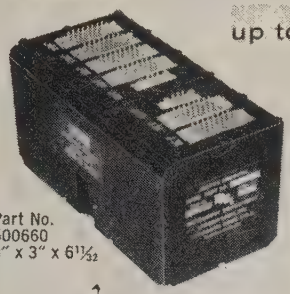


FIRST PRACTICAL RADIOISOTOPIC FUELED GENERATOR

NEW 4-Pole PAM Telemetering Commutator

up to 180 Data Channels @ 5 rps

fm/fm Telemetering . . .



Part No. 500660
3" x 3" x 6½"

This 4-pole switch combines two pairs of PAM commutating sections. One pair consists of two poles, each pole capable of sampling 30 MBB channels. The other pair is capable of sampling 60 MBB channels per pole. A single 28 volt d.c. ungoverned motor drives all switching sections. The switch is designed and built to withstand space, explosive and airborne environmental conditions in Missiles, Rockets, and other applications.

Poles #1 & #2 — 60 MBB contacts each
Poles #3 & #4 — 30 MBB contacts each
Phasing — ± 100 microseconds in each set
} 5 rps Pole speeds

Standards: Military MIL-E-5272, MIL-I-6181B

Temperature	Operating, —20°F to +185°F
Altitude	0 to 100,000 feet
Vibration	15g² per cycle per second; 25-2000 cps random; 5 minutes each on 3 axes
Shock	100g, 10 millisecs, sawtooth, six directions
Acceleration	45g for 2 seconds in six directions
Service Free Life	200 hours guaranteed; 500 hours expected
Insulation Resistance	100 megohms at 300 volts d.c.
Hi Potential Test	500 volts, 60 cycle a.c., 1 min. each lead to ground

See us in IRE Booth #2106

IDL

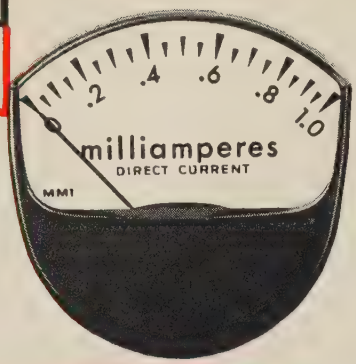
Complete specifications and drawings available on Technical Bulletin No. 500660

INSTRUMENT DEVELOPMENT LABORATORIES, INC.
Subsidiary of Royal McBee Corporation
67 MECHANIC STREET, ATTLEBORO, MASSACHUSETTS, U.S.A.

Write in No. 136 on Reader Service Card at start of Product Preview Section

marion

advancement in instrument design



ACTUAL SIZE

MM-1 MEDALIST* meter

Today's most readable, modern miniature meter. Shielded — no error from magnetic panels. Rugged Marion Coaxial mechanism. Max. weight 1.6 oz. In all standard ranges, various colors. Single hole mounting. Data on request. Marion Instrument Division, Minneapolis-Honeywell Regulator Co., Manchester, New Hampshire, U.S.A. *In Canada, Honeywell Controls Limited, Toronto 17, Ontario.*

Honeywell

75 YEAR PIONEERING THE FUTURE — First in Control — SINCE 1885

Write in No. 137 on Reader Service Card

FOR LEAK-DETECTION DEVICES

OHIO

NITROUS OXIDE

EASILY SNIFFS OUT MICROSCOPIC LEAKS

Infrared determination of nitrous oxide provides a safe, sensitive and flexible method of leak detection. This method is not affected by usual atmosphere components such as moisture, carbon dioxide and hydrocarbons. In addition, nitrous oxide will not harm pieces being tested and is more economical than other gaseous agents.

OHIO NITROUS OXIDE: ODORLESS AND INERT • NONTOXIC • NONCORROSIVE • NONFLAMMABLE • ECONOMICAL

FREE TECHNICAL AID is available in the use of nitrous oxide for leak detection. For further information, please request the following bulletins:

1A Chemical, Physical and Pharmacological Properties of Nitrous Oxide with Results of Corrosion Tests

1B Gas Service Equipment for Nitrous Oxide Supply

OHIO *Ohio Chemical*

OHIO CHEMICAL & SURGICAL EQUIPMENT CO.

(A Division of Air Reduction Company, Incorporated) AIRCO

MADISON 10, WISCONSIN

Write in No. 138 on Reader Service Card

SERVO MOTOR *is inertia damped*

This size 18 inertia-damped servo motor is 2.525 in long and provides an upper corner frequency of 27 cps. It is designed for systems requiring additional stability without a reduction of steady state velocity, says **Beckman Instruments, Helipot Div., Dept. S/A, 2500 Fullerton Rd., Fullerton, Calif.** Model 18 IM 460 operates from a 115 V 400 cycle source to deliver 2.35 oz inches of torque at stall.

It weighs 18 oz, has stainless steel case, shaft and bearings and is completely encapsulated. It will withstand 20 G vibration up to 500 cps, 200 deg C total unit temperatures and meets humidity requirements of MIL-E-5272A.

Write in No. 284 on Reader Service Card

SIGNAL GENERATOR *for 400-450 mc*

The Model BSG-7 signal generator although primarily developed as a test unit for FM radio receivers, may be used wherever frequency modulated r-f carrier signals of precise frequency and amplitude are necessary. Units are available covering any consecutive 15 frequencies of discrete one mc spacing over the range of 400-450 mc with variable carrier deviation from 0 to ±300 Kc and r-f signal accuracy of 0.01 per cent according to **Babcock Radio Engineering, Inc. Dept. S/A, 1640 Monrovia Ave, P. O. Box 344, Costa Mesa, Calif.**

Internal modulation providing the first six standard a-f channels or external modulation up to 80 Kc is included as a design feature of the equipment. Units are available in either the self-contained bench type or standard 19 in rack mounting configuration.

Write in No. 285 on Reader Service Card

more on page 206

Don't ruin a valuable piece of equipment merely because some part is rusted tight. Apply Kroil, the amazing new chemical lubricant that creeps into millionth inch spaces (proved by laboratory tests), dissolves rust, supplies necessary lubrication and

LOOSENS FROZEN PARTS

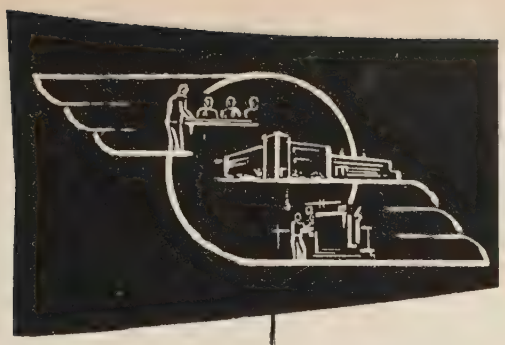
18,000 of America's leading plants can't be wrong! They have used KROIL for 10 years and are still depending on it to save expensive labor and valuable parts. They say: "Kroil loosened bushings after a 12-ton press had failed" . . . "on repairing heat treat trolleys formerly destroyed every nut. Now Kroil saves them all, and time, too" . . .

You too should be using KROIL every day. Try it on money-back basis. Gallon **$4.35**; with Kroiler trigger squirt gun (shoots a drop or a stream 15 feet, if desired) **$5.25**; f. o. b. our factory.

KANO LABORATORIES 1097 Thompson Lane, Nashville 11, Tenn.

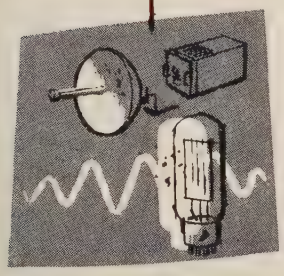
KANO LABORATORIES

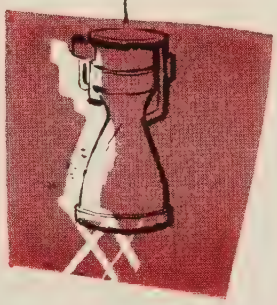
Write in No. 139 on Reader Service Card

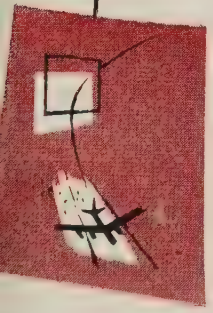


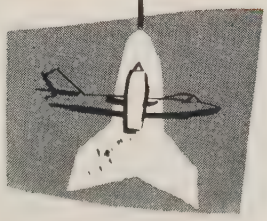
DIVERSIFICATION

means HEALTHY BALANCE at BELL









Diversification is healthy for a defense contractor, its customers, and for the nation. Here's a brief look at today's broadly diversified activities of the Niagara Frontier Division of Bell Aircraft Corporation.

Bell rocket engines are pushing an Agena into polar orbit with each launching under the Discoverer program. The Air Force has contracted for a Bell all-weather automatic landing system already proven in thousands of actual demonstrations. Bell reaction controls are being used on the X-15 and are being readied for Mercury. Bell accelerometers make up part of the guidance systems for the Army Sergeant and other missiles. The nation's first deflected jet VTOL experimental aircraft, designed and built by Bell, has been flight tested by NASA.

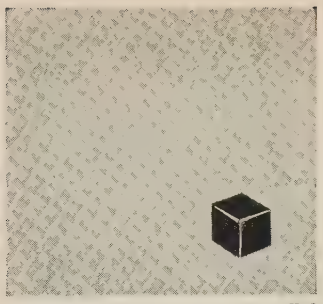
Bell is also actively engaged in many other highly advanced technical projects. These, to name a few, embrace such fields as double-wall construction, automatic drone control, ducted propeller VTOL aircraft, ground effect vehicles, revolutionary new battlefield surveillance techniques and extremely accurate, highly sensitive complete inertial guidance systems for aircraft, missiles and space vehicles.

That is what Bell means by broad diversification within the defense industry. That is why the proven engineering and production capabilities of Bell's Niagara Frontier Division can serve you so well in so many ways.

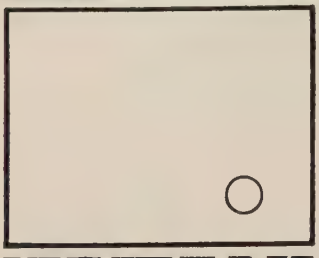
BELL AIRCRAFT CORPORATION

Niagara Frontier Division

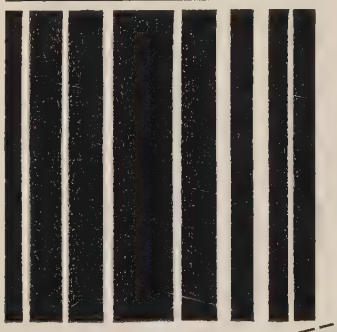
BUFFALO 5, NEW YORK



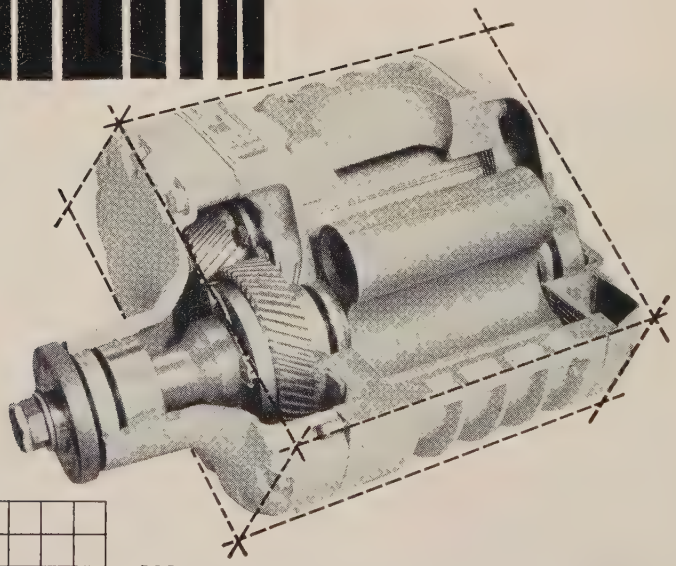
SMALLEST CUBE DIMENSIONS

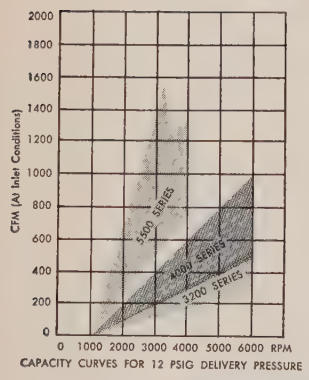


LIGHTEST WEIGHT



WIDEST PRESSURE RANGE





WITH M-D 3-LOBE BLOWERS

If space and weight of the blower is a concern in your design problem, consider this fact. M-D rotary positive blowers because of their unique 3-lobe design require smaller cubic space than any other blowers. A survey shows that a 14 PSI M-D takes 3/4 to less than 1/10 the space of competitive models . . . and in some cases are only 1/10 the weight.

M-D Blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 11 production models range from 50 to 4000 CFM, pressures to 14 PSIG single, 70 PSIG multi-stage.

For full information write

M-D BLOWERS, INC., RACINE, WISCONSIN
A Subsidiary of Miehle-Goss-Dexter, Inc.

Write in No. 141 on Reader Service Card at start of Product Preview Section

TEFLON TERMINAL for heavy duty

This "Press-Fit" type FT-SM-36 TUR-LI meets heavy duty requirements and has a current rating of 10 amps continuous duty, along with a stepped-up safe operating voltage of 1750 dc at sea level, says **Sealectro Corp., Dept. S/A, 139 Hoyt St., Mamaroneck, N. Y.**

Write in No. 286 on Reader Service Card

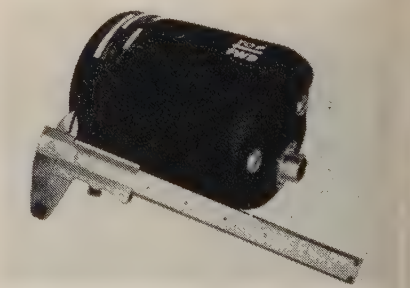
PLANETARY REDUCER has variable drive

This planetary reducer enables a high torque, infinite range drive having speed ranges from 300 revolutions per minute to zero to 1 revolution per hour to zero with speeds accurately set to one part in four thousand, says **Graham Transmissions, Inc., Dept. S/A, Menomonee Falls, Wisc.** It develops a torque of 100 inch pounds.

Built-in overload protection prevents damage to the reducer, transmission or driven machinery. In-line design is said to be space saving and permits a package of motor, variable speed drive, control and reducer that is mounted with only four bolts.

Write in No. 287 on Reader Service Card

VERTICAL GYROSCOPE for target and drone aircraft



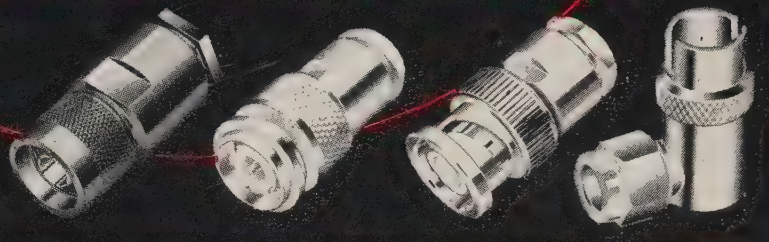
This vertical gyroscope for use in target and surveillance drone aircraft, designated the NV3203, is said to be highly reliable and is available in ac or dc, says the **Iron Fireman Mfg. Co., Electronics Div., Dept. S/A, 2838 S.E. Ninth Ave., Portland 2, Ore.**

It provides pick-offs on both roll and pitch axes to indicate displacements from vertical.

Write in No. 288 on Reader Service Card

EARTHBOUND AND BEYOND

CANNON RF COAXIAL PLUGS MEET ANY CHALLENGE... ANYWHERE



CANNON PLUGS

Cannon's **complete** line of RF coaxial plugs meet the exacting demands of today's technology with room to spare! Wherever coaxial cable is used; land, sea, air, or outer space, Cannon's RF plugs—standard, miniature, and light-weight aluminum—provide the exact type and size for any application . . . whether industrial or military • Aircraft • Missiles • Ground Support Equipment • Ships • Submarines • Write for literature to:

CANNON ELECTRIC CO., 3208 Humboldt Street, Los Angeles 31, California • Please refer to Department 115

Largest Facility in the World for Plug Research—Development—Manufacture

Write in No. 142 on Reader Service Card at start of Product Preview Section

Ground Power Problems? ...Here is the Answer!

Whatever your requirements in 400 cycle ground power equipment, E-M's large staff of specialists, with unmatched 400 cycle generator experience, can help. Missiles and jet aircraft that now have the advantages of E-M's imaginative engineering of 400 cycle ground power generators include Titan, Nike-Hercules, Snark, Matador, Hound Dog, B-47, B-58, and B-52.

Designing and building 400 cycle generators to meet the exacting requirements of missile and jet applications requires a big investment in experienced, technical manpower and plant facilities. Ask your nearby E-M Field Engineer to show you his copy of "Ground Power for Space". It's an informative picture story of E-M's investment in your 400 cycle ground power needs.

FREE 28-PAGE ILLUSTRATED BOOKLET offers many answers to your 400 cycle ground power questions. Write the factory for a free copy of "ABC of 400 Cycle Generators and Their Control". It's packed with useful information about performance characteristics and mechanical construction of 400 cycle ground power generators.

E-M ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota
2600-TPA2220A

Write in No. 143 on Reader Service Card at start of Product Preview Section

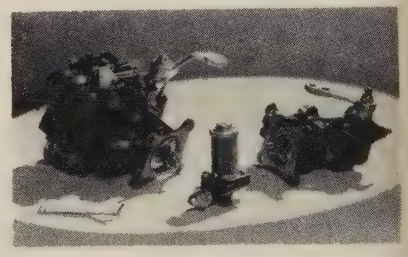
GLASS CLOTH *is Teflon-impregnated*

This laminated plastic made from glass cloth impregnated with Teflon resin features low permeability and high dielectric strength, says **Continental-Diamond Fibre Corp., Dept. S/A, Newark 107, Del.** Known as Dilecto GB-108TED, it is designed for corrosive applications.

The material is offered as continuous, natural-color, smooth-finish sheet in coils, in 0.009 in standard thickness, although thicknesses of 0.008 in and 0.007 in can also be supplied. Maximum width available is 6 in, maximum length 75 ft.

Write in No. 289 on Reader Service Card

CONTROL SYSTEM *for lightweight turbines*



This engine control system meets the requirements of small, high performance, lightweight gas turbine engines from 100 to 750 hp. It consists of 3 components: main fuel control, power turbine governor for free turbine engines, and optional air temperature compensator, says **Bendix Aviation Corp., Dept. S/A, So. Bend 20, Ind.** It is applicable to all types of small gas turbine engine requirements.

Total weight is less than 4 lbs. On applications where all the 3 components are not required to meet engine specifications, the system weight would be reduced.

Write in No. 290 on Reader Service Card

SPECIAL NETWORK *increases transmitter power*

The Model SP-58-1A Symmetra-peak is a special network designed to increase effective power and coverage range of voice transmissions on AM, FM, TV audio, SSB and HF communications, says **Kahn Research Labs., Inc., Dept. S/A, 22 Pine St., Freeport, L.I., N.Y.**

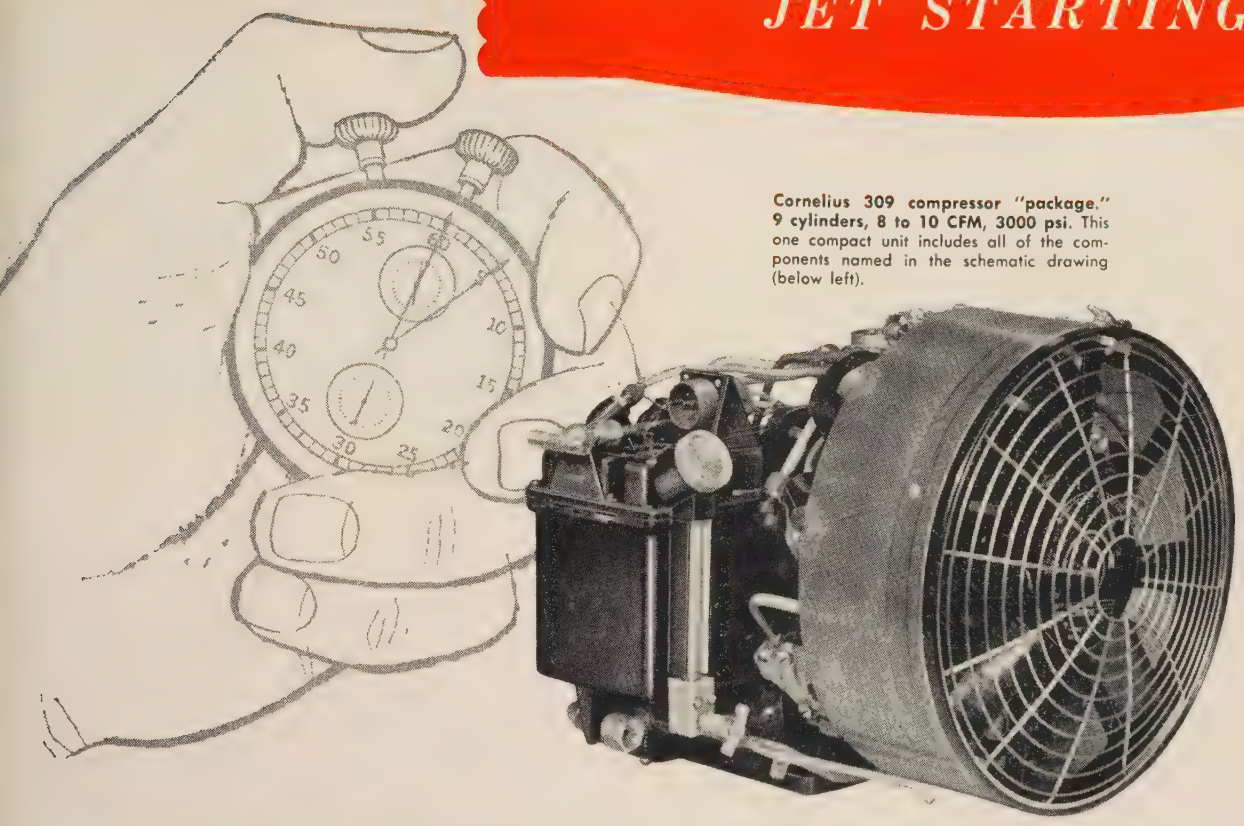
Symmetra-peak redistributes unequal positive or negative peak energy contained in most voice waves equally about the zero axis. No power source is required, and there is nothing to wear out or replace in normal service.

Write in No. 291 on Reader Service Card

more on page 211

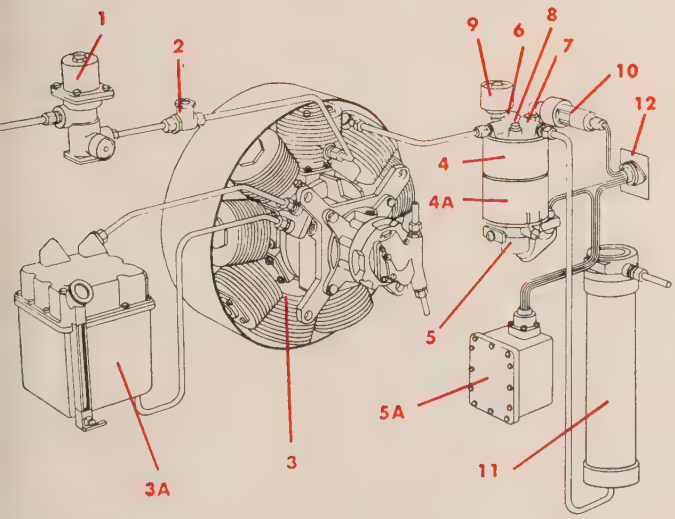
. . . important news about

JET STARTING



Cornelius 309 compressor "package." 9 cylinders, 8 to 10 CFM, 3000 psi. This one compact unit includes all of the components named in the schematic drawing (below left).

for reliable "split-second" jet starting equip your jets with Cornelius compressors



1. Absolute Pressure Regulator 2. Vacuum Breaker 3. Air Compressor with Hydraulic or Electric Motor 3A. Oil Reservoir 4. Moisture Separator 4A. Thermostatically Controlled Heater Blanket 5. Condensate Dump Valve 5A. Condensate Exhaust Timer and Relay 6. Check Valve 7. Back Pressure Valve 8. Switch Rupture Disc 9. System Relief Valve 10. Pressure Switch 11. Chemical Drier 12. AC-DC Power Input

The Cornelius 309 compressor "package" will soon be operational on five major domestic airlines and five major foreign airlines. It has also been selected for installation on the Allison Prop-Jet Super Convair. This pneumatic system was developed to give jets better, faster starts. It is unmatched for reliability, capacity and longer life. It improves the performance of any jet or prop-jet equipped with a fuel-air starting system.

Here are some facts that demonstrate Cornelius equipment superiority: The 309 compressor is the largest capacity compressor now in production and flying. Its 8 to 10 CFM air delivery is 50 per cent greater than any other available compressor. This larger CFM delivery means greater reliability and longer life because less "ON" time is required for air reservoir recovery; is ideal for short flights.

Specify Cornelius as original equipment. Whether you are an airline or an airframe manufacturer, you are guaranteed to receive a compressor package that is the last word in design and performance — a compressor *second-to-none.*

For *retrofit* programs, replace your small, less reliable compressors with Cornelius 309 compressors. There's a 309 package for every application and it will reduce your maintenance, overhaul and operating costs.

For complete information, qualification test data and installation drawings, contact us today.

THE *Cornelius* COMPANY / *Aero Division*

553 - 39th Avenue N.E. • Minneapolis 21, Minnesota

Pioneers in pneumatic systems for aircraft.

Write in No. 144 on Reader Service Card at start of Product Preview Section

Reaching for the Moon, Mr Designer?

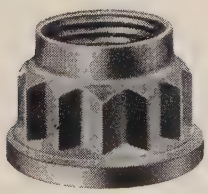
Here's a tip... Millions of Kaylock® nuts ago, a new aircraft fastener made its bow... the Kaylock H20, first lightweight, high tensile, all-metal, self-locking nut.

Its significant improvement over then-existing fasteners – lighter weight, greater strength, smaller envelope – won immediate acceptance by airframe weight engineers and designers.

Today, with a premium on weight and space savings in aero-space vehicles and engines, design engineers depend more than ever on Kaylock nuts. So here's a tip...

If you're reaching for the moon, Mr. Designer, reach for your up-to-the-minute Kaylock catalogs first. Chances are, *your* "brainchild" will *get there sooner.*

Fastener with a past – that's the Kaylock H20. A favorite callout of design engineers for the past 3 years, the H20 was the first high tensile, all-metal nut using the elliptical self-locking principle for which Kaylock nuts are famous. "Vital statistics" include:



Service Temperature: 550°F
Tensile Strength: 180,000PSI
Material: Alloy Steel

Ready to Help – Here are a few of the Kaylock external wrenching nuts built to meet rigid requirements in weight and space reduction.

H14 — Service Temperature: 550°F
Tensile Strength: 160,000PSI
Material: Carbon Steel

H23 — Service Temperature: 550°F
Tensile Strength: 180,000PSI
Material: Alloy Steel

H24 — Service Temperature: 550°F
Tensile Strength: 220,000PSI
Material: Alloy Steel

H41 — Service Temperature: 900°F
Tensile Strength: 125,000PSI
Material: A286 CRES

H33 — Service Temperature: 1200°F
Tensile Strength: 160,000PSI
Material: A286 CRES

H19083 — Service Temperature: 1400°F
Tensile Strength: 160,000PSI
Material: M252 CRES

H10 — Service Temperature: 550°F
Tensile Strength: 125,000PSI
Material: Carbon Steel

H31 — Service Temperature: 900°F
Tensile Strength: 125,000PSI
Material: A286 CRES

Kaylock
ALL METAL SELF-LOCKING NUTS

TRADE MARK

KAYNAR MFG. CO., INC.– KAYLOCK DIVISION • *World's largest and oldest manufacturer of lightweight, all-metal, self-locking n*
Home office and plant: Write Box 2001, Terminal Annex, Los Angeles 54, California
Branch offices, warehouses and representatives in Wichita, Kansas; New York, N. Y.; Atlanta, Georgia. Canadian Distributor: Abercorn A[illegible]o, Ltd., Montreal, Qu

GENERATOR gives sequential gate pulses

This unit is designed to generate sequential gate pulses. Operation is continuous, even with one or several information gates removed. Active readout capability is from 1 to 88 channels, operating on all standard IRIG sampling rates of 30, 45, 60, or 90 channels at from 75 to 900 pps according to **Arnoux Corp. Dept. S/A, 11924 W. Washington Blvd., Los Angeles 66, Calif.**

The unit is adaptable to any Arnoux Decommutator, or may be adapted to any system requiring sequential timing pulses, such as digital computers, analog to digital converters, etc.

Write in No. 292 on Reader Service Card

TIME INDICATORS are subminiature

This sub-miniature hermetically sealed elapsed time indicator operates on 115 V 60 cps supplies. The digital model has 5 digits reading to 9999.9 hours in tenth-hour increments. Two dial type models are offered: one reads to 2500 hours in 5-hour increments and one reads to 10,000 hours in 10 hour increments, says **A. W. Hayden Co., Dept. S/A, Waterbury, Conn.** All models use a miniature 60 cycle motor drawing less than 3 watts.

The unit is enclosed in 1¼ in diameter housing. They are filled with a dry nitrogen atmosphere.

Write in No. 293 on Reader Service Card

COOLING FAN with slotted blade

This lightweight aircraft fan delivers large volumes of air at high pressure and low inborne noise. It provides 450 cfm of cooling air at total pressure of 22 in water gage. Contained in a compact space envelope, the fan measures 7½ in long, weighs 7.8 lbs, and has a 2.4 hp motor which drives a small 4 in impeller at 22,500 rpm, says **General Dynamics Corp., Electric Boat Div., Dept. S/A, Groton, Conn.** The use of slotted blades extends laminar boundary layer flow over a larger portion of blade surface.

Higher aerodynamic loading is said to be possible without stall propagation.

Write in No. 294 on Reader Service Card

PRESSURE GAGES are highly accurate

This series of pressure gages, made in compound and vacuum types, is individually dead-weight tested and guaranteed accurate within ±¼ of 1% for use in laboratory and other critical applications. The dial features permit the gage to be read with the accuracy of a caliper rule, according to **Marsh Instrument Co., Dept. S/A, Skokie, Ill.**

Designers of the "master-test" gages are in dial sizes 4½", 6" and 8" in many case patterns.

Write in No. 295 on Reader Service Card

BLOCK & VENT VALVE has straight-through flow

This ¼ in block and vent valve is designed for control air service utilizing one operator. Air flow is straight through at operator pressures of 5.5 psi or greater. As the operator pressure drops to 3.5 psi, air service is blocked, and when it reaches 2 psi or less the cavity between the blocked ports is vented to atmosphere, according to **George W. Dahl Co., Inc., Dept. S/A, 86 Tupelo St., Bristol, R. I.**

The body pressure rating is 30 psi and the body temperature rating is for ambient air only.

Write in No. 296 on Reader Service Card

more on next page

← Write in No. 145 on Reader Service Card

BRISTOL

chopper meets reliability standards of Army "Hawk"

PHOTO COURTESY OF RAYTHEON COMPANY, WALTHAM, MASS.

Every part that goes into a modern-day missile system must pass a rigid battery of tests and a thorough statistical screening to insure highest possible reliability in action.

That's why we're pleased to announce that Bristol Syncroverter choppers play an important role in guidance of the U.S. Army HAWK missile, produced by Raytheon Company, Waltham, Mass., prime contractor for the complete HAWK weapons system.

Billions of operations. Bristol Syncroverter* choppers are ideal for applications requiring the utmost in statistical reliability. The Bristol life-test lab has now had miniature Syncroverter choppers running for years without failure—both with and without contact load. Just one sample: five choppers with 400-cycle drive and 12v, 1ma, resistive contact load have completed 26,000 hours (2.96 years) continuous operation—over 37-billion operations!

actual size

An extremely wide variety of standard models is available—including external coil low-noise types. For complete data, write: Aeronautical Components Division, The Bristol Company, 150 Bristol Road, Waterbury 20, Conn.

*T. M. REG. U. S. PAT. OFF. 9.26

BRISTOL FINE PRECISION INSTRUMENTS FOR OVER SEVENTY YEARS

Write in No. 146 on Reader Service Card

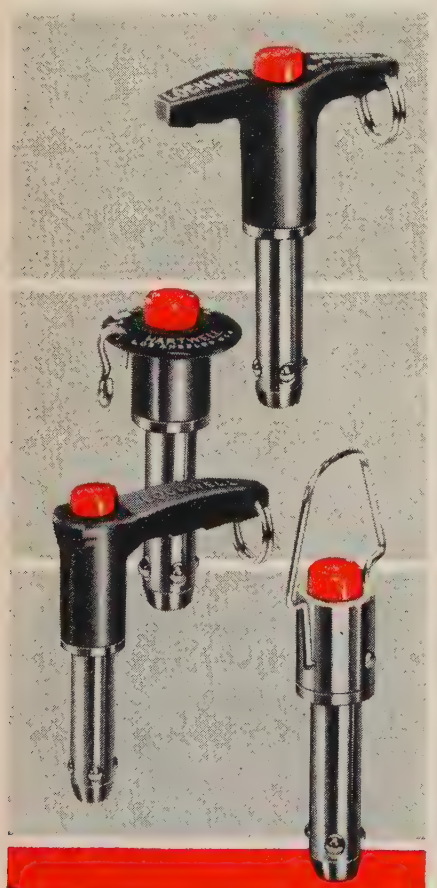
LOCKWELL*
newest . . . most advanced
quick release pins

Lockwell Quick Release Pins offer the finest replacement for nuts and bolts where Optimum Safety and Speed of Release are of vital importance.

GREATER SAFETY — Exclusive 4-ball locking element — Oversize *RED* release button — Fail-Safe design allows pin to operate if handle is broken.

ADVANCE DESIGN — Gripwell handles for maximum operation — Steel shoulder bearing provides best resistance to wear — Black and red functional finish.

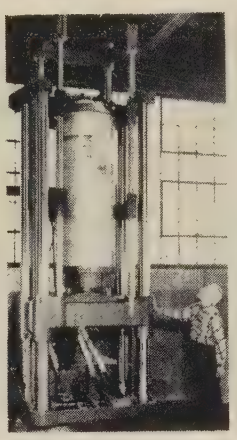
SPECIAL DESIGNS — In addition to standard configurations, Lockwell features can be incorporated into pins to meet special design requirements. Your inquiry is sincerely invited.



HARTWELL AVIATION SUPPLY COMPANY
9035 VENICE BOULEVARD
LOS ANGELES 34, CALIFORNIA
20 YEARS OF FASTENER LEADERSHIP
Branch Offices in Hackensack, Chicago, Wichita, Ft. Worth and Seattle
* Trade Mark

Write in No. 147 on Reader Service Card

HANDLING MACHINE for rocket engines

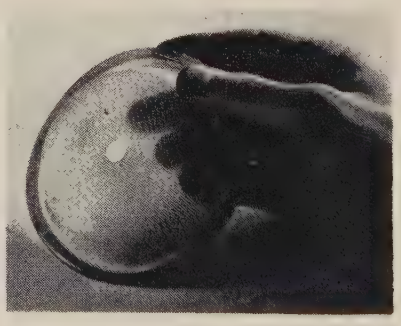


This is designed to handle solid propellant rocket engines during radiological inspection and each function is hydraulically actuated. Dimensions permit inspection of 6000 lb engines, 5 to 10 feet long and about 36 in in diameter, according to **Barnes & Reinecke, Inc., Dept S/A, 230 E. Ohio St., Chicago, Ill.** Change over from one engine to another can be done by changing fixtures.

With the X-ray tube on the axis of the engine, the machine is traversed vertically a distance corresponding to the engine's length. Transducers transmit signals to counters with present digital indications of the precise area being scanned.

Write in No. 297 on Reader Service Card

DIAPHRAGM SEALS for high temperatures



This high-temperature, long-stroke, rolling diaphragm seal for aircraft, missiles, rockets and other control and regulator applications is designed to operate at temperatures up to 550 deg F. The seal is thin walled offering maximum stroke, flexing life and sensitivity, says **Bellofram Corp., Dept. S/A, Blanchard Rd., Burlington, Mass.** Standard sizes are available in one to six inches in diameter with a maximum stroke of up to 4 in.

Four different classes of mounting configurations are available for simplified installation.

Write in No. 298 on Reader Service Card

more on page 214

For Excellence
TEFLON
TUBING

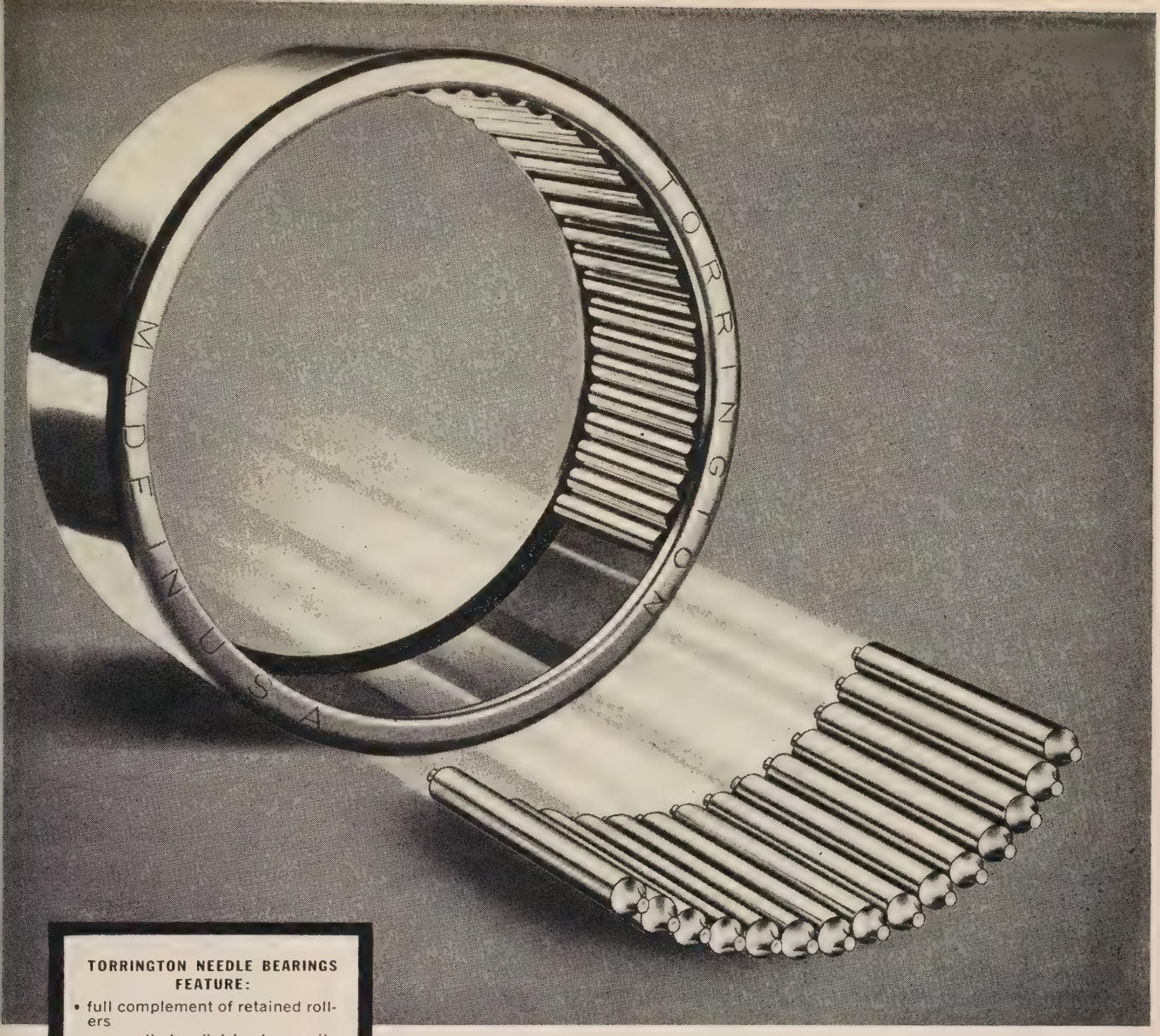
Teflon* tubing is well known to be chemically inert, to resist abrasion, and to stay flexible at extreme temperatures.
For mechanical, chemical, aeronautical and electrical uses, extruded tubings of Teflon and other plastics bearing the FLEXITE trademark assure you dependable performance through precision manufacturing by MARKEL—with whom excellence has been a credo since 1922. Name your need; let Markel send samples and data.

*Du Pont Trademark

MARKEL
SINCE 1922

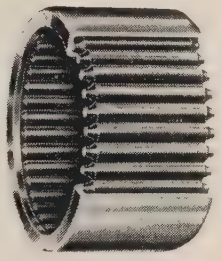
L. FRANK MARKEL & SONS
Norristown Pennsylvania

Write in No. 148 on Reader Service Card



TORRINGTON NEEDLE BEARINGS FEATURE:

- full complement of retained rollers
- unequalled radial load capacity
- low coefficient of starting and running friction
- low unit cost
- long service life
- compactness and light weight
- runs directly on hardened shafts
- permits use of larger and stiffer shafts



Here's Why Torrington Needle Bearings Provide Maximum Radial Load Capacity

The Torrington Needle Bearing's full complement of small diameter rollers provides the largest possible number of bearing contact lines in the load zone.

This feature gives Needle Bearings a higher radial load capacity than any other bearing of comparable size. Precision rollers ensure smooth anti-friction performance with low coefficient of starting and running friction, to match this unequalled capacity. Rollers are positively retained by the turned-in lips of the outer shell, permitting simple, economical installation and assembly.

Torrington experience spans twenty years in design and application of Needle Bearings to equipment of all types. This experience is at your disposal to help you secure the ultimate in performance built into every Torrington Needle Bearing. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

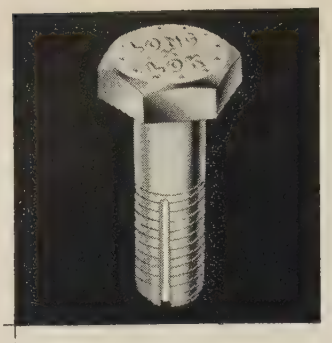
TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

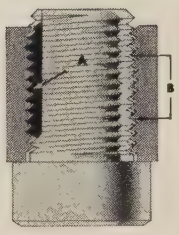
NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

Write in No. 149 on Reader Service Card at start of Product Preview Section

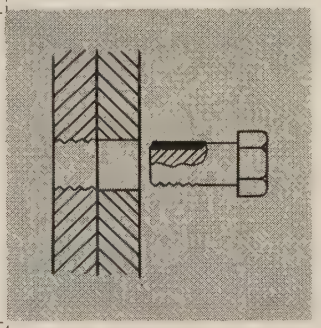
This is a LONG-LOK Self-Locking Screw. It is a one-piece reusable fastener, heat, vibration, impact and shock resistant.



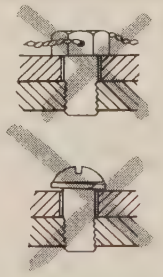
It is vibration resistant because the resilient, reformable insert (A) acts as a wedge between the male and female threads, causing a metal-to-metal drag (B).



LONG-LOK Self-Locking Screws are flush protruded and pass through normal clearance holes with finger pressure. No special clearance holes are required.



LONG-LOK Self-Locking Screws save time and money because they eliminate safety wire (and head drilling), and lock washers. They also save weight.



LONG-LOK Self-Locking Screws are available for aircraft, missile and commercial applications. They meet MIL-F-18240 Specifications and can be head marked for self-lock identification.

Write for Catalog LL-60

LONG-LOK
CORPORATION

2601 COLORADO AVENUE
SANTA MONICA, CALIFORNIA
UPton 0-6335 • TWX S MON 7146

Licensees and Representatives in Principal Cities

Write in No. 150 on Reader Service Card

TRANSDUCER
for high pressure

This high pressure transducer is designed to measure differential pressure between two high pressure sources. They can use virtually any media as the high pressure reference. Model 704 incorporates a stainless steel bourdon tube so corrosive fluids such as nitric acid can be used, while model 706 utilizes a beryllium copper or NI-SPAN-C bourdon tube for use with non-corrosive media, according to **Bourns, Inc., Dept. S/A, P. O. Box 2112, Riverside, Calif.** Both models have stainless steel cases sealed to withstand pressures of 1000 psig.

Specifications include pressure range, 0-100 to 0-5000 psid: linearity, ±0.75 per cent; resistances, 1000 to 10,000 ohms: size, 1¾x2$\frac{1}{32}$ in: weight about 8 ozs. They meet MIL-E-5272A procedure 1 for shock and acceleration.

Write in No. 299 on Reader Service Card

SOLENOID
operates at 1000 deg F

This ultra-high-temperature solenoid operates continuously at ambient temperatures up to 1000 deg F. The device is intended for aircraft and missile applications where engine or re-entry temperatures render ordinary solenoids inoperative, says **Rocker Solenoid Company, Dept. S/A, 140 North Marine Avenue, Wilmington, Calif.**

The new ultra-high-temperature unit is designed for strokes of from .010 in to .060 in. At .010 in stroke the compact solenoid will operate a minimum force of 15 lbs. It requires a power source of 18 to 30 V dc. Coil resistance at 1000 deg F is 35 ohms. Diameter is 1⅞ in and the unit weighs 1.3 lbs.

Write in No. 300 on Reader Service Card

more on page 216

GROW WITH AIRESEARCH
IN ELECTRONICS

AiResearch expansion in electronics and electromechanical activity is creating outstanding positions at all levels for qualified engineers.

FLIGHT SYSTEMS RESEARCH

General problems in motivation and navigation in air and space; required background in astronomy, physics, engineering.

Openings also exist in the following areas: Data Systems Research... Controls Analysis... Flight Data Components... Electromagnetic Development... Instrument Design... Airborne Instrumentation Analysis and Design.

Send resume to: Mr. Robert Richardson

THE GARRETT CORPORATION

AiResearch Manufacturing Division

9851 So. Sepulveda Blvd., Los Angeles 45, Calif.

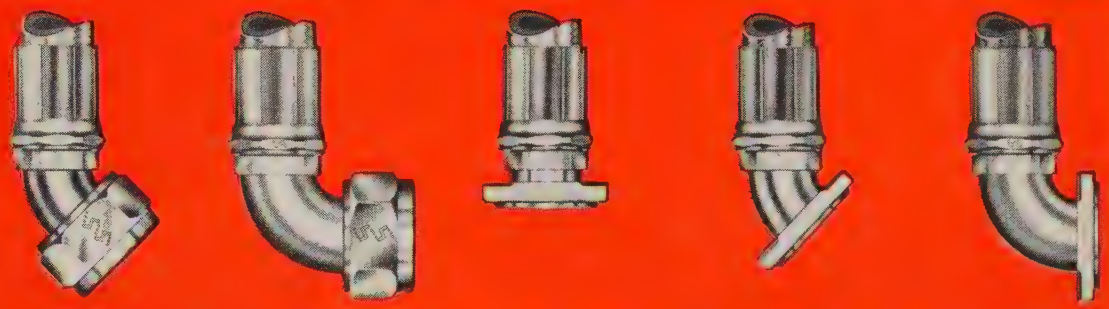
Check Employment Inquiry Form on Page 161

PROVEN PERFORMANCE and RELIABILITY . . .

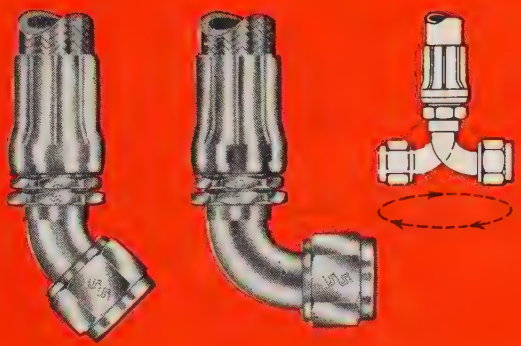
Contributing to maintenance-free operation on today's aircraft and missiles

STRATOFLEX Teflon* HOSE

"SUPER-T" MEDIUM PRESSURE



SUPER "T-HP" HIGH PRESSURE



Designed for reliability and flexibility at temperatures ranging from —65° to 450°F, Stratoflex "Super-T" and Super "T-HP" Teflon Hose exceed the rigid requirements of MIL-H-25579 and MIL-H-8788 (ARP 604) respectively. The stainless steel braided cover hose and inner tube of Teflon has an operating range of 1500 PSI to 3000 PSI and is used to convey the following fluids: fuels, oils, acids, solvents, alcohol, high pressure gases, as well as liquid gas transfer service. Fittings are made from all corrosion resistant steel or a combination of both carbon steel and corrosion resistant steel. Assemblies are available with straight, 45° and 90° elbows. Other angles are available to your specifications.

*Teflon is a registered DuPont trademark

Write now for Stratoflex "Super-T" Bulletin S-3 or Super "T-HP" Bulletin S-7, or Aircraft Catalog.

SF11-9

STRATOFLEX Inc.

P.O. Box 10398 Fort Worth, Texas
Branch Plants: Hawthorne, Cal., Fort Wayne, Toronto
In Canada: Stratoflex of Canada, Inc.

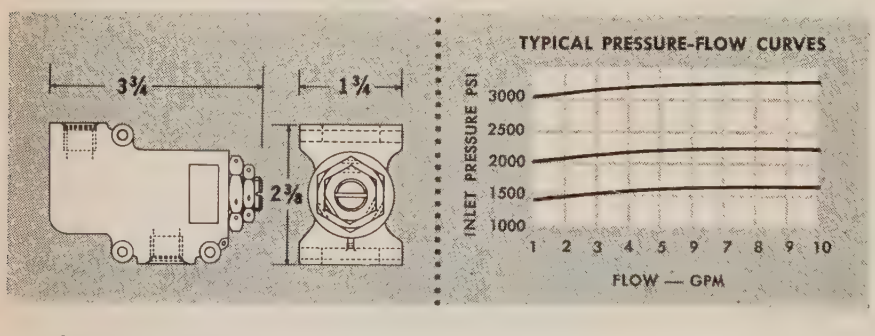
SALES OFFICES:
Atlanta, Chicago
Cleveland, Dayton
Detroit, Fort Wayne
Fort Worth, Hawthorne
Houston, Kansas City
Milwaukee, New York
Philadelphia, Pittsburgh
San Francisco, Seattle
Toronto, Tulsa

Write in No. 152 on Reader Service Card at start of Product Preview Section

- **Good Repeatability**
- **Accurate Pressure Control**
- **Extremely Stable**
- **No Hysteresis**
- **Pilot Operated**

This precision valve is just one of the many pressure and flow control valves and devices Fluid Regulators Corporation has designed and produced to meet customer's exacting weight, size and performance specifications. It features low pressure rise and modular (cartridge) construction for easy maintenance.

For good, fast, practical solutions to your hydraulic pressure and flow control problems write us today.



SPECIFICATIONS

- Performance: exceeds MIL-V-5523B
- Outline And Mounting: meet AN 6279-6
- Mounts: on either side
- Operating Pressure (adjustable): 100 to 4,000 psi in three ranges
- Temperature Ranges: —65° to +275° F.
- Weight: 11 oz.
- Ports: AND 10050-6
- Materials: Aluminum And Stainless Steel
- Part No.: 7485

Cartridge valve only is also available

Write for detailed literature

Designers and manufacturers of hydraulic and fuel valves for aircraft missiles, rockets, ground handling and support equipment.

Fluid Regulators CORPORATION

313 Gillette Street • Painesville, Ohio • ELmwood 2-3319

Write in No. 153 on Reader Service Card at start of Product Preview Section

DECADE COUNTER meets extreme environmental conditions

Type DC-130 takes advantage of shock and vibration characteristics of the magnetically shielded Beam Swtiching Tube, type BD-301. It resolves pulses up to 110 Kc, can be directly cascaded, and provides 10 individual outputs which are capable of operating remote Nixie indicator tubes, print-out devices, as well as performing many other decimal functions such as variable scale countings, says **Burroughs Corp., Electronic Tube Div., Dept. S/A, P.O. Box 1226, Plainfield, N.J.** Actual field operating tests have been performed which verify the ability of the units to withstand high shock, vibration, and blast test waves without damage or error.

Write in No. 301 on Reader Service Card

MATING JACK & PLUG are microminiature

This "Press-Fit" SKT-31 jack and mating PR-10 plug have general breakaway connector usages. The PR-10 probe is .040 in dia, while the SKT-31 jack is designed to accept a .040 in dia. Both members are provided with solder cups so that straight leads can be attached in very close quarters without wrapping, says **Sealectro Corp., Dept. S/A, 139 Hoyt St., Mamaroneck, N. Y.**

Terminals can be mounted closely on .187 in centers plus or minus minimum normal tolerances.

Write in No. 302 on Reader Service Card

TRANSPARENT VINYL is fungus-resistant

This transparent, fungus-resistant vinyl insulation sleeving, resinite EP-69C, conforms to Navy spec MIL-I-631C, grades a and b, for electrical insulation applications. Designed for use in aircraft, it is expected to find use in the automotive industry, says **Borden Chemical Co., Dept. S/A, Santa Barbara, Calif., or No. Andover, Mass.**

Characteristics are low-temperature flexibility to –75° F. high-temperature stability to 185° F., and dielectric strength to 900 V per mil of wall tickness. Material is self-extinguishing in 6 sec.

Write in No. 303 on Reader Service Card

more on page 218

BENDIX SR RACK AND PANEL CONNECTOR

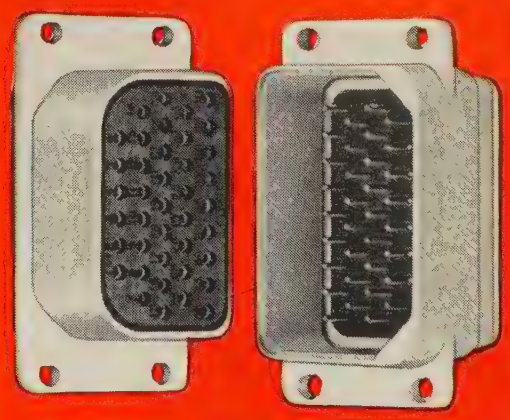
with outstanding resistance to vibration

The Bendix type SR rack and panel electrical connector provides exceptional resistance to vibration. The low engagement force gives it a decided advantage over existing connectors of this type.

Adding to the efficiency of this rack and panel connector is the performance-proven Bendix "clip-type" closed entry socket. Insert patterns are available to mate with existing equipment in the field.

Available in general duty, pressurized or potted types, each with temperature range of −67°F to +257°F.

Here, indeed, is another outstanding Bendix product that should be your first choice in rack and panel connectors.



FEATURES:

Resilient Insert • Solid Shell Construction • Low Engagement Forces • Closed Entry Sockets • Positive Contact Alignment Contacts—heavily gold plated Cadmium Plate—clear irridite finish • Easily Pressurized to latest MIL Specifications.

SCINTILLA DIVISION
SIDNEY, NEW YORK

Bendix
AVIATION CORPORATION

Export Sales and Service: Bendix International Div., 205 E. 42nd St., New York 17, N. Y.
Canadian Affiliates: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec.
Factory Branch Offices: Burbank, Calif.; Orlando, Florida; Chicago, Illinois; Teaneck, New Jersey; Dallas, Texas; Seattle, Washington; Washington, D. C.

Write in No. 154 on Reader Service Card at start of Product Preview Section

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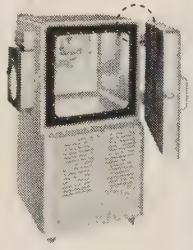
CINCINNATI SUB-ZERO CHAMBERS feature

RUGGED CONSTRUCTION

Cabinet heavily built to most exacting test requirements . . . for dehydrating gases, simulating hi-lo temperature conditions, accurate calibration of instruments . . . through

Custom Engineered Design

- Rounded corners, for greater strength
- Unitized all-metal with no seams; electric welded
- "Toe-room" base, with skids or casters
- Phosphatized, to prevent rust
- Easily removable, expanded metal grille guards, for quick access to refrigeration system



For literature and estimates write

CINCINNATI SUB-ZERO PRODUCTS

General Offices & Plant
3930-V Reading Rd. • Cincinnati 29, Ohio

Representatives in major industrial areas
Member: Environmental Equipment Institute

Write in No. 155 on Reader Service Card

CLOSURES

- **Metal or Plastic Caps or Plugs to protect threads, tubes, machined parts, reamers, cutters, tools.**
- **Protect against thread damage, dust, dirt, and moisture.**
- **For inside and outside application. All sizes. Immediate delivery.**

Clover closures are made in metal and tough plastic polyethylene. They are made in caps, plugs and special shapes to fit parts tightly, offering completely sealed protection during manufacture, shipping and storage. Backed by years of closure experience. Write for low prices and complete information.

METAL Caps to cover AN & SAE threads

PLASTIC tapered caps and plugs

METAL plugs for AN & SAE threads

PLASTIC tube cap for AN & SAE parts

Send coupon today!

Gentlemen: Please send samples and prices of closures in Polyethylene ☐ Aluminum ☐

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Address.....

City.....

CLOVER INDUSTRIES, INC. 602 Young Street Tonawanda, N. Y.

Write in No. 156 on Reader Service Card

STABLE SUPPLIES for airborne data systems

The Series 2-300 power supplies are completely transistorized devices that bring the principles of ground strain-gage supplies to flight-test use, says **Neff Instrument Corp., Dept. S/A, 2211 E. Foothill Blvd., Pasadena, Calif.** The supplies are designed for high-temperature, high-g environments and have a life expectancy of 10,000 operational, trouble-free hrs.

The units provide one or three amps at five, ten or 15 V to transducers or other airborne devices. Stability is 0.1 per cent, frequency variations are under ±.05 per cent for 360 to 440 cps, and drift is ±.05 per cent, measured over a 24-hr period. Temperature rane is —55 to +85 deg C with a ±1-per cent variation and the devices will operate at altitudes to 70,000 ft.

Write in No. 304 on Reader Service Card

more on page 220

BOND IN BOTTLES

Well... not really in bottles. But, now you can get Super-Strength LEFKOWELD 2-Component Paste Type Adhesives in handy, disposable, high-grade polyethylene kits*. LEFKOWELD is accurately *pre-proportioned* for you. Clean, safe, convenient blending of adhesive and activator. Your hands are safe from irritating chemicals. Just a few simple steps and LEFKOWELD is ready to apply. Newest! Safest! Fastest! and Easiest! way to apply adhesives... the LEFKOWELD Adhesive Kit.

SUPER-STRENGTH LEFKOWELD ADHESIVES

Up to 4500 psi tensile shear strength

Bond rigid or semi-rigid, like or unlike materials

Resistant to oil, moisture, gasoline, hydraulic fluid

Stable under widely varying temperatures

LEFFINGWELL L SINCE 1900

*Semco "Semkits" Patent No. 2,838,210 Semco Research, Inc.

Lefkoweld formulations are ideal for assembly, maintenance and repair. Technical data and recommendations on request.

Write today

LEFFINGWELL CHEMICAL COMPANY
P.O. Box 1187, Perry Annex, Whittier, Calif.

Write in No. 157 on Reader Service Card

Lamb® six-pole 400 cycle AC motor for operation submerged in jet fuel for booster pump drive. Frame: 2⅞ x 2½

Lamb® 27 volt DC shunt wound aircraft motor qualified to specification MIL-M-8609A (ASG) for small high speed pumps. Frame: 1²⁵/₃₂ x 1⅛

Lamb® six-pole 400 cycle AC gear-motor for voltage regulating auto transformer. Frame: 1¾ x ⅞

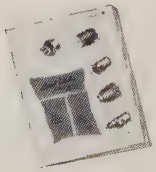
Lamb® two-pole 60 cycle AC motor for electronic cooling fan. Frame: 2¼ x ¾

Lamb Electric works in so many fields —where motors that have vastly different jobs to do are sold to vastly different markets — that experience gained in one field often helps solve problems in other fields.

For example, we are able to incorporate in motors for appliances, portable electric tools, and similar products, developments that came about in research and engineering work on military and other precision motors.

This broad experience—available to all of our customers—is one way in which Lamb Electric special application motors can help your product stay ahead of competition.

Let us demonstrate the value of this experience in bringing to *your customers* improved products and to *you* more business and better profits.



Write for your copy...
8-page folder describes these and other Lamb Electric motors.

THE LAMB ELECTRIC COMPANY
KENT, OHIO
A Division of American Machine and Metals, Inc.

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

In Canada: Lamb Electric Division of Sangamo Company Ltd.—Leaside, Ontario

Write in No. 158 on Reader Service Card at start of Product Preview Section

Clearing Aircraft & Missile Division reports:

Parts before and after hot sizing.

A More Efficient Method for Forming Space Age* Metals to 1800 Degrees F. and above

titanium *beryllium *molybdenum *mag-thorium *precipitation hardened stainless steels

laterials, impossible to form at room temperatures, become orkable at elevated temperatures since ductility is generally ncreased and yield strength decreased. Hot sizing eliminates urnace forming, reduces or eliminates springback and stress elieves parts.

Clearing retractable bed hot platen presses are available with orming tonnages of 75, 150 and 300 tons exerted vertically and orizontally. Platen surface areas—9 square feet to 20 square eet. Building block design allows several presses to be "ganged" nd operated individually, or in any combination of units.

Presses, like the above, are also well suited to low temperature astic laminating.

USI Clearing
division of U.S. Industries, Inc.
Aircraft and Missiles Division
6160 S. Boyle Ave., Los Angeles 58, California, Ludlow 5-2141
Main Plant: 6499 W. 65th St., Chicago 38, Illinois, PO 7-8700

Look for the CLEARING NAME on these products

Mechanical Presses • Hydraulic Presses • Torc-Pac C.B.I. Presses • Axelson Lathes • Harrison Lathes • Special Equipment for Aircraft and Missiles Mfg. • Dies • Torc-Pac Drives • Research and Development

Write in No. 159 on Reader Service Card at start of Product Preview Section

Engineering notes from the

SMI REPORTER

By STANLEY M. INGERSOLL, *Capabilities Engineer*

Report No. I

A new advance in pressure switching is embodied in our TR 2065. Through the use of solid state switching circuits*, SMI has developed a pressure switch which is extremely accurate and highly reliable. This new unit supplies a switch closure or opening on either an increasing or decreasing pressure and is ideally suited to applications where severe environments of temperature, vibration and shock are encountered.

For example, exhaustive tests of a 500 PSI unit have shown that it will not chatter when subjected to 50G's vibration when the pressure input is only 0.2% away from the switch point.

Essentially the TR 2065 is an SMI Bourdon Tube Pressure Transducer coupled with unique solid state switching circuits. The result is a pressure switch which is friction free and contains no moving parts in contact.

Principles of Operation As switching pressure is applied to the interior of the helically twisted Bourdon Tube, the tube rotates the armature attached to its end. The armature is positioned in a miniature, balanced, inductive bridge. A solid state electronic circuit receives the signal from the bridge and performs an extremely reliable switching function using minute amounts of energy, due to the elimination of friction and the minimizing of inertial forces.

Additional switch points may be added to the TR 2065 without adding more pressure sensing elements. Thus, as the number of operations increases, the size, weight and cost per switching point decreases.

Typical Specifications

Switch Point

Dynamic Stability:
Less than 0.25% of full scale when subjected to 60G's shock (10 m.s.) and vibration and 100G's shock

Vibration:
(10-55 cps 0.2" SA) (55-2000 cps 60g)

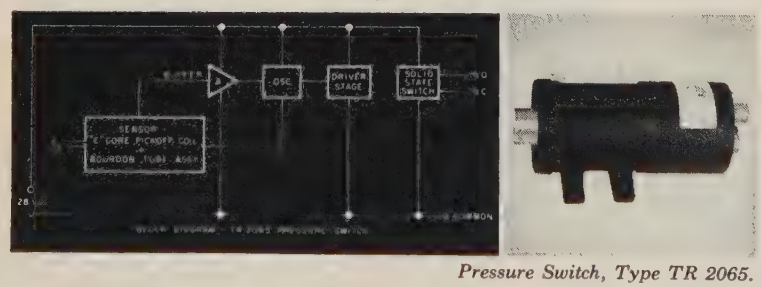
Hysteresis
0.1% of the pressure cycle experienced by the tube

Temperature:
(zero shift) 0.005% per °F
(scale factor) 0.001% °F

Long Term Drift
0.2% per year (approx.)

On-Off Differential
0.1% or better

Repeatability
0.1% of full scale



Pressure Switch, Type TR 2065.

What are your needs? If your immediate or future applications call for pressure switching, write or wire for complete information. Address your inquiry to Stanley M. Ingersoll, Capabilities Engineer.

**Patent applied for*

SMI

SERVOMECHANISMS, INC.

Los Angeles Division
12500 Aviation Boulevard
Hawthorne, California

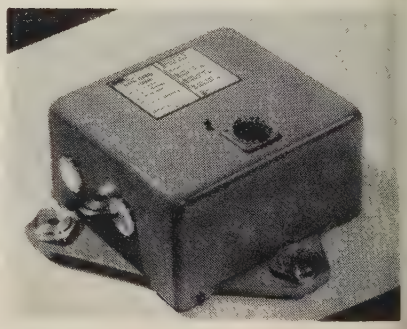
LAMINATED PLASTIC cuts circuit fire hazard

EP-37, a laminated plastic that will not support combustion, has been developed for use in high-quality printed circuits, such as computer circuits, in which high voltages present a fire hazard, says **Formica Corp., Dept. S/A, 4614 Spring Grove Ave., Cincinnati 32, O.** The copper-clad paper epoxy base material also features a high degree of dimensional stability, and excellent insulation resistance and punchability.

EP-37 offers greater resistance to plating solutions because of a new adhesive that secures the copper to the base laminate. The laminate shows no blistering when it is subjected to 500 deg F for as long as 15 sec, in a solder bath.

Write in No. 305 on Reader Service Card

RATE GYRO SYSTEM has three axes



This 3-axis rate gyro system includes a telemetering network and other circuitry, and provides information pertinent to pitch, roll and yaw rates. Assembly and inspection techniques are said to assure stability and result in low null values, low hysteresis, excellent linearity and resolution, according to **Giannini Controls Corp., Dept. S/A, 918 E. Green St., Pasadena 1, Calif.**

One degree maximum gimbal deflection is said to be one of its features.

Write in No. 306 on Reader Service Card

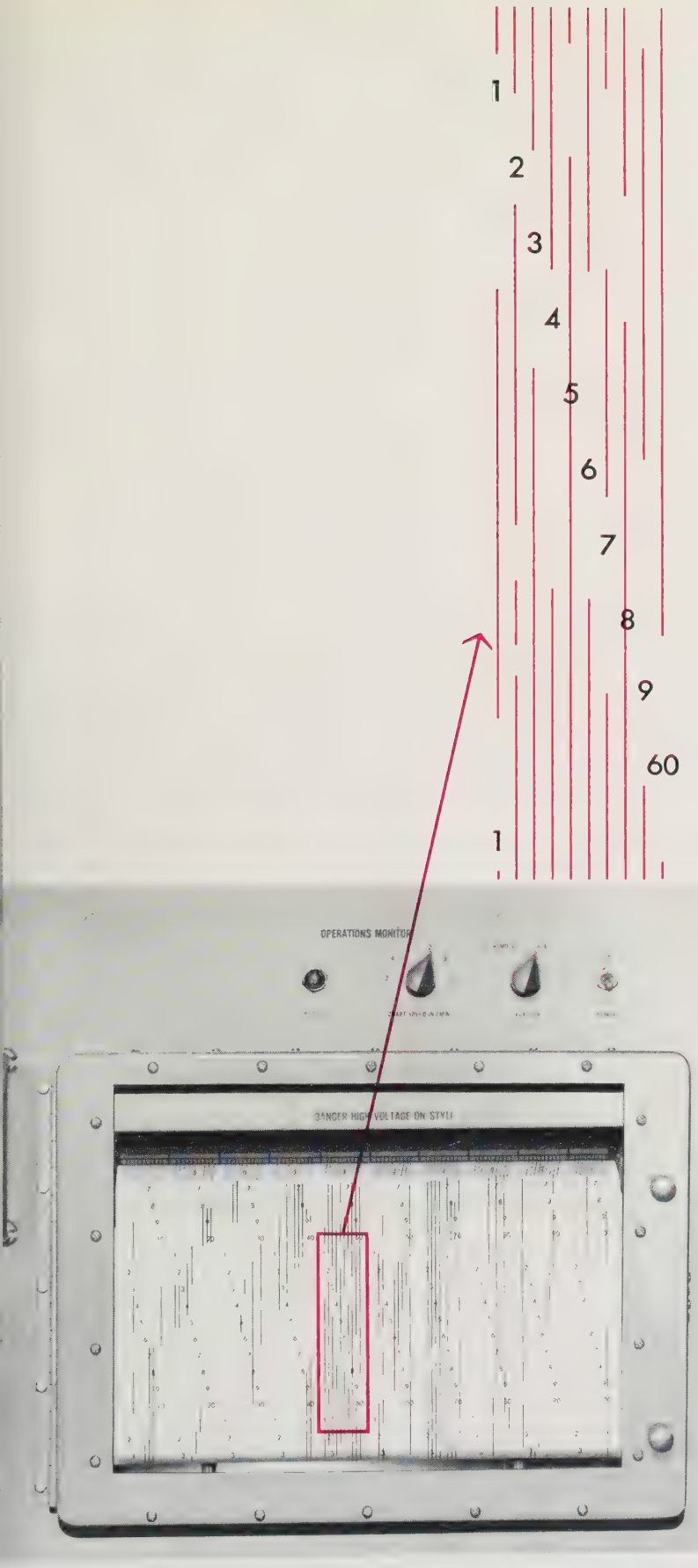
SWITCHING TRANSISTOR has high gain

This series of nine power transistors is especially designed for the use in power switching and power control circuits, such as d-c/d-c converters and regulated power supplies, says **Bendix Aviation Corp., Red Band Div., Dept S/A, Long Branch, N.J.**

The transistors have the highest dc current gain ratings of any power units in production. The series has a 5 ampere maximum current rating and can switch power up to 400 w.

Write in No. 307 on Reader Service Card

more on page 223



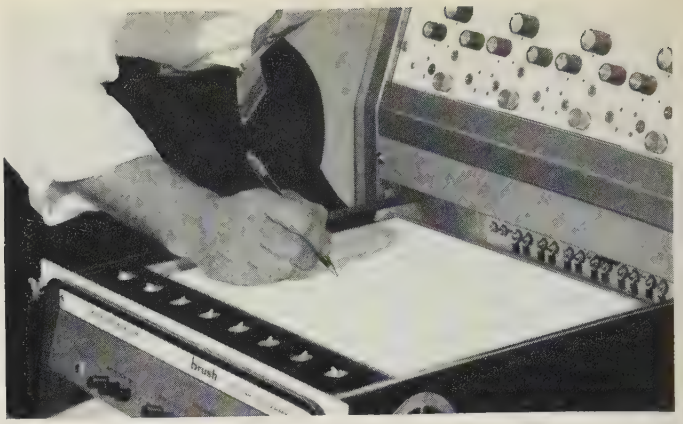
insight at 4 milliseconds

recorded with Brush operations monitors. Multiple high-speed events are reported in writing within 4 milliseconds of occurrence—to establish the basis for split-second, million dollar decisions necessary in today's complex control systems. Up to 120 separate "on-off" event signals are monitored and permanently recorded on a chart only 12″ wide. Fixed-stylus electric writing provides sharp, reproducible traces of uniform clarity. Chart speeds from one to 250 mm/sec permit a precise interpretation of all events, with resolution up to 500 signal changes per second. For military or industrial analysis and control, no direct writing recording system can match the capabilities of Brush Operations Monitors. Write today for complete specifications and application data.

brush INSTRUMENTS

DIVISION OF

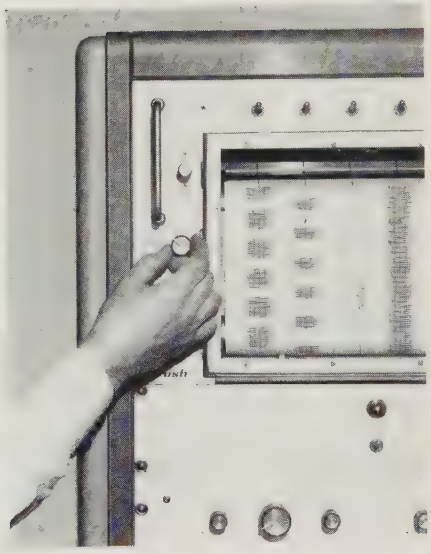
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

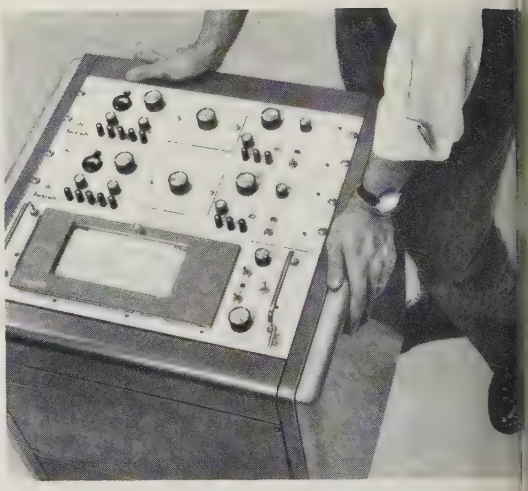


in direct

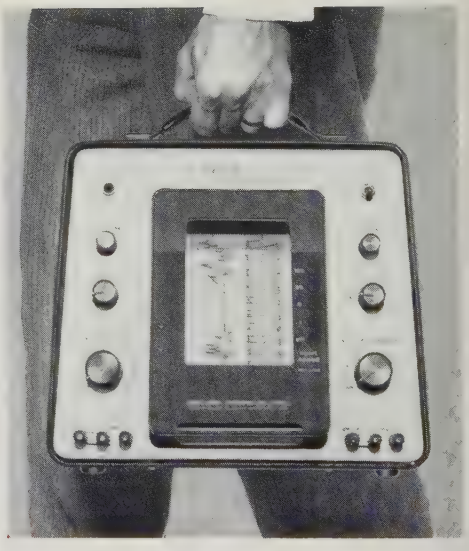
writing

systems





only Brush eliminates compromise



Avoid a "second best" choice. Get exactly what you need. Only Brush permits selection of . . . **Writing Method** . . . ink, electric or thermal . . . **Trace Presentation** . . . curvilinear or rectilinear . . . **Configuration** . . . vertical or horizontal, rack mounted or portable models. Also . . . chart speeds from 50″/sec to 10″/day . . . functionally designed control panels . . . readily accessible components for fast inspection, simple adjustment . . . complete, easy to understand operating manuals. Get the industry's most advanced design concepts. You never need compromise when you specify Brush. Complete information at your request.

brush INSTRUMENTS

DIVISION OF

37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

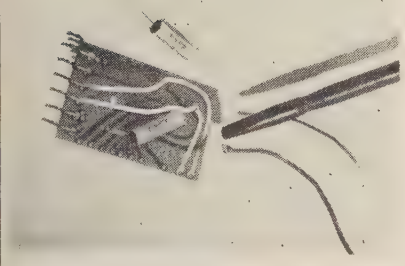
DC MOTOR weighs 5 pounds

This model C-1360 light weight, 28v motor has a rectangular type frame for operation on dc power sources. It delivers .33 hp at 8400 rpm continuous duty and .50 hp at 7700 rpm, says the **Hoover Electric Co., Dept. S/A, Hangar Two, Port Columbus Airport, Columbus, Ohio.** It is 6.500x2.875x3.125 in and weighs 5 lbs.

The rectangular frame is said to provide greater power output with less space and weight.

Write in No. 308 on Reader Service Card

VERY SMALL RELAY has one msec speed



A spdt relay with a one-msec operating time and a three msec release time is one of the smallest, most flexible, general-purpose relays ever developed, says **General Electric Co., Dept. S/A, Schenectady 5, N.Y.** The Unimite is under one in long and **about ¼ in** in diameter.

The device can be cycled at 10,000 operations per min. Size and low power requirements (240 mw) permit its use in multiples to satisfy a variety of contact arrangements. Contacts are rated at one amp at 28 V dc, and they meet the overall requirement of MIL-R-5757C and MIL-R-25018. The relay has been shock tested to 40 g and vibration tested to 30 g from 55 to 2000 cycles per second. The design has virtually eliminated contact contamination.

Write in No. 309 on Reader Service Card

SAMPLING SWITCH features high speed

This noiseless sequential sampling switch, capable of more than 3600 closures a second, is actuated by a rotating jet of air, the only moving part. The Roto-Jet wiperless switch has a high speed switching where a large number of voltage-generating elements must be connected successively to a single load, says **Electric Regulator Corp., Dept. S/A, Norwalk, Conn.** Signals of one, two, and three millivolts can be transmitted free from noise without amplification or filtering.

Sampling speeds are available up to 40 revolutions per second.

Write in No. 310 on Reader Service Card

more on next page

R/M CAPABILITY creates a new flame-barrier

To meet the stepped-up firewall requirements for some of America's "hottest" jets, R/M engineers were required to develop a barrier material which would resist flame-penetration up to 1800°F and operate at ambient temperatures as high as 500°F without appreciable absorption of fuels and solvents.* Furthermore, the material had to remain flexible even at temperatures as low as –40°F.

Because of R/M's exceptional capability in the packing field, the problem was tackled and solved to the customer's complete satisfaction.

The answer in this case was development of R/M-RL641—Viton† Inconel‡ wire-reinforced sheet. Viton's resistance to heat, chemicals, jet fuels and solvents—and at extreme temperatures—is in a range completely new in the elastomer field. Coated cloths, tadpole tape, channel tape, and other products put R/M capability to work.

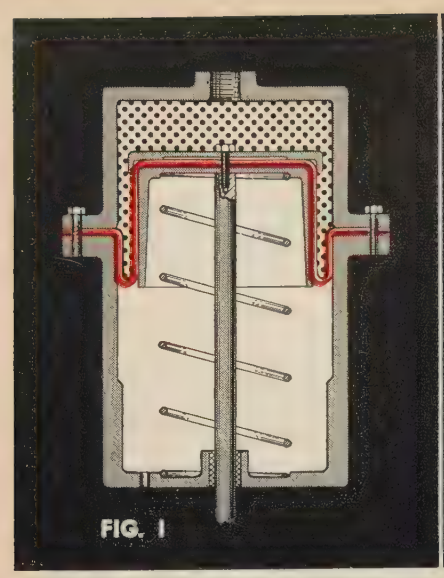
Write for complete information and literature.

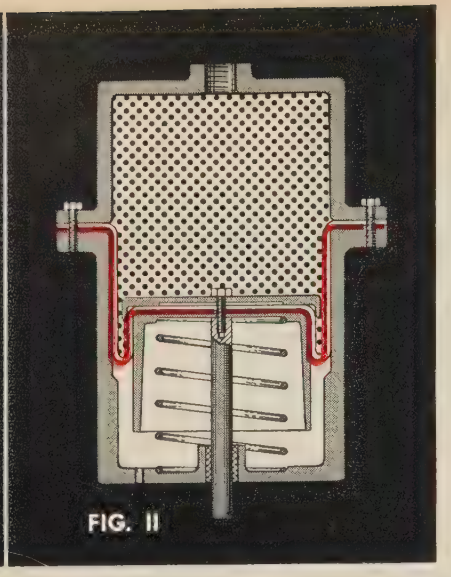
*Meeting FAA regulations.
† Viton is a DuPont trademark
‡ Inconel an International Nickel trademark

R/M PACKINGS
RAYBESTOS-MANHATTAN, INC.
PACKING DIVISION, PASSAIC, N. J.
MECHANICAL PACKINGS AND GASKET MATERIALS

Write in No. 130 on Reader Service Card at start of Product Preview Section

← Write in No. 163 on Reader Service Card





For Hydraulic and Pneumatic Applications

Nothing rolls like a Bellofram® Rolling Diaphragm. It's frictionless!

The Bellofram Rolling Diaphragm provides ultrasensitive response in hydraulic or pneumatic devices where frictionless, long-stroke action in small-diameter configurations is required . . . and where flex life of millions of cycles is necessary.

These desiderata are achieved through the *rolling* action of a flexible thin-sidewall diaphragm consisting of a high-tenacity fabric overlay embedded in elastomeric material.

Fig. I shows how Bellofram Rolling Diaphragm conforms to the piston. Fig. II shows how, as the piston descends under pressure, the diaphragm *rolls* off the piston's sidewall and onto the cylinder's sidewall in a smooth, continuous, frictionless movement.

The Bellofram principle can be applied widely in actuators, pumps, instruments, seals, accumulators, fluid dampers, etc.

Which of these advantages are you looking for?

To the designer confronted with situations for which conventional bellows, O-rings, or cup packings are inadequate, Bellofram Rolling Diaphragm offers a constellation of advantages found in no other product:

1. Friction-free (low hysteresis).
2. No break-out friction effects.
3. Completely leakproof device.
4. Constant area in all piston positions.
5. Almost infinite flex life (millions of cycles).
6. Sensitivity to extremely small pressure changes.
7. No mechanical spring gradient.
8. Compatibility with practically all environmental gases or fluids.
9. Automatic de-icing action.
10. Free positioning with complete relaxation at any point in its stroke.
11. Does not require close machine finish tolerances on pistons and cylinders.
12. Freedom from abrasive wear.
13. One hundred stock sizes. Four mounting configurations. Special types and sizes designed to order.
14. Excellent temperature stability, from —85°F. to 550°F. (from —120°F. to 700°F. in some cases).

Wide range of working pressures: 1 in. H_2O to 500 psi (up to 1200 psi in some cases).

Effective pressure areas from .028 to 108 sq. in.

Cylinder bore diameters from .25 to 12 in.

Extended range of stroke (.01 to 12 in.).

Send for Free Literature

Bellofram®

®Reg. trademark U.S.A. and foreign countries • Bellofram Rolling Diaphragms are protected by U.S.A. and foreign patents.

BELLOFRAM CORPORATION, 11 BLANCHARD ROAD, BURLINGTON, MASSACHUSETTS

TOGGLE SWITCH is extremely small

This midget toggle switch, identified as T4201, is for application where space, weight and durability are vital factors. The toggle is capped in a gray silicone rubber boot in model T4202, says **Hetherington, Inc., Dept. S/A, 1420 Delmar Dr., Folcroft, Pa.** Rate for 1 amp at 28 v dc resistive load at sea level.

The overall length is 57/64 in and a case diameter of 21/64. Recommended panel mounting hole is ¼.

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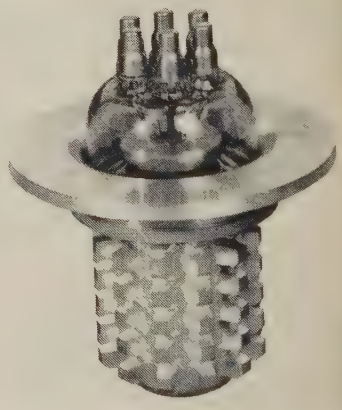
POWER TUBES have long life



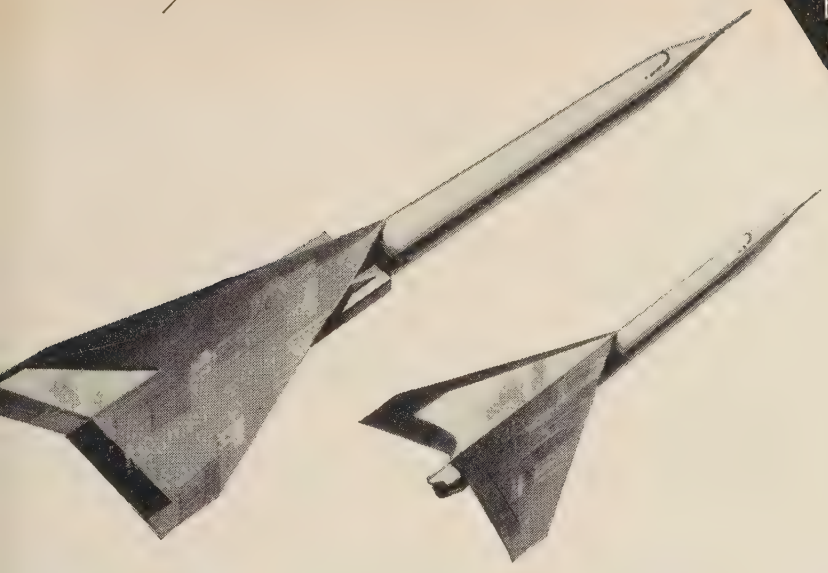
Reliability and long life have been achieved in a line of high temperature power tubes, according to **ITT Components Div., International Telephone & Telegraph Corp., Dept. S/A, Clifton, N. J.** The tubes are useful in modulators, amplifiers and oscillators in communications equipment, and in induction heaters for metal processing, among other industrial equipment.

A vapor cooling technique is used to increase heat dissipation beyond that possible with conventional air- or water-cooled tubes. Anode dissipations exceeds 800 W/sq in and dissipation of 2500 W/sq in has been maintained for several minutes without damage to the tubes. The tubes are noiseless and need no rotating parts.

Write in No. 312 on Reader Service Card

more on page 228

New steels are born at Armco



MCO PRECIPITATION-HARDENING STAINLESS STEELS . . .

sed in Today's Aircraft--
lanned for Tomorrow's

Armco's high strength-weight ratio stainless steels, PH 15-7 Mo, 17-7 PH and 17-4 PH, are widely used in our newest missiles, fighters, and bombers, and in *all* the new jet-powered commercial airliners.

They are specified for airframe structures and skins, pod assemblies, engine parts, accessories and instruments because they have a unique combination of properties—light-weight strength at temperatures to 900-1000 F, good corrosion resistance, and excellent fabricating characteristics that assure economical producibility.

These properties have given designers new opportunities to create reliable components that withstand the heat and stresses of jet-propelled flight . . . and save weight.

Tomorrow's aircraft now on drawing boards, will utilize the many advantages offered by these special Armco Stainless Steels to solve some of the complex problems imposed by speeds of Mach 2 and beyond.

Consider the design and production possibilities of Armco Precipitation-Hardening Stainless Steels for the units *you* are making or designing. Mail the coupon for complete information on their properties and fabrication.

ARMCO STEEL CORPORATION
3439 Curtis Street, Middletown, Ohio
Send me data on these Armco Stainless Steels:
☐ Armco PH 15-7 Mo
☐ Armco 17-7 PH
☐ Armco 17-4 PH

NAME_____
COMPANY_____
STREET_____
CITY_____ ZONE_____
STATE_____

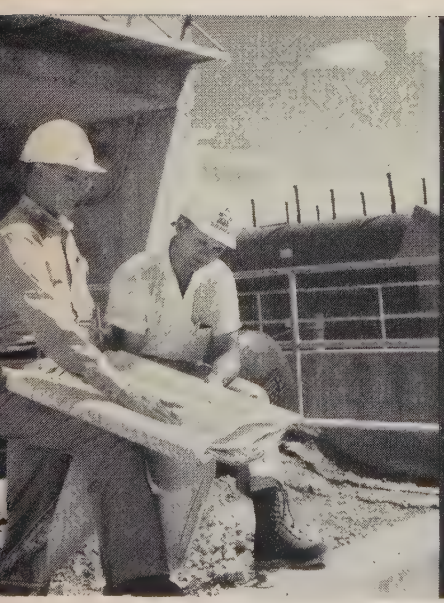
ARMCO STEEL

ARMCO®

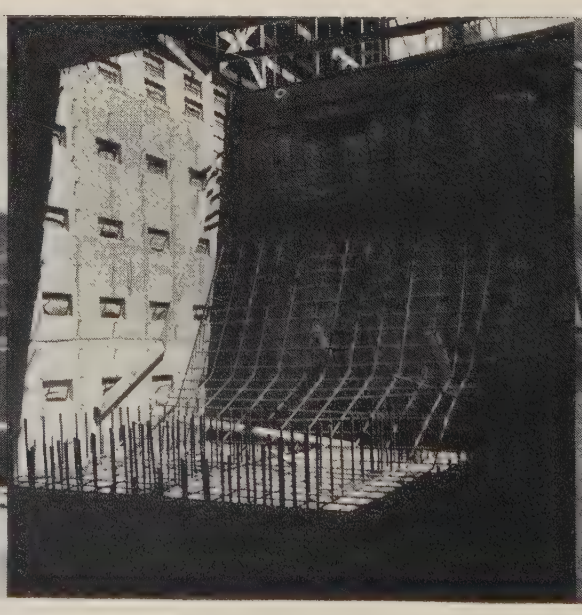
Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

Write in No. 151 on Reader Service Card at start of Product Preview Section

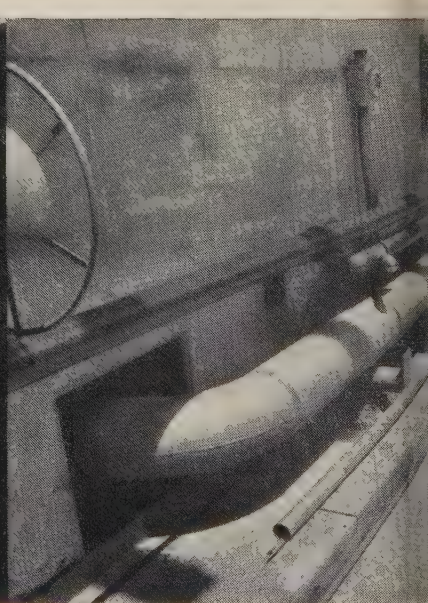
Somewhere east of Laramie, on one of Wyoming's plains, you'll find the strangest government housing project ever built. Six concrete and steel buildings are being constructed to house Atlas missiles. The site is one of the operational intercontinental missile bases to be operated by the Strategic Air Command. This base is being constructed on the surface. Follow-on bases will burrow deep into the earth. In all these systems, the Air Force puts much emphasis into ground support equipment. Virtually all steels required can be purchased from one firm — United States Steel. Whether it's carbon



The U. S. Army Corps of Engineers is constructing this operational intercontinental missile base in Wyoming. In front of the partially completed Launch and Service Buildings are Col. Sidney T. Martin, in charge of construction, and Maurice K. Graber, a construction engineer for the Corps.



This is the inside of the blast pit of one of the launcher buildings. In all six of these buildings there are 1,040 tons of structural steel, 1,950 tons of reinforcing steel, over 48,000 tons of concrete aggregate, blocks and cement, and 8,040 tons of mechanical steel items.



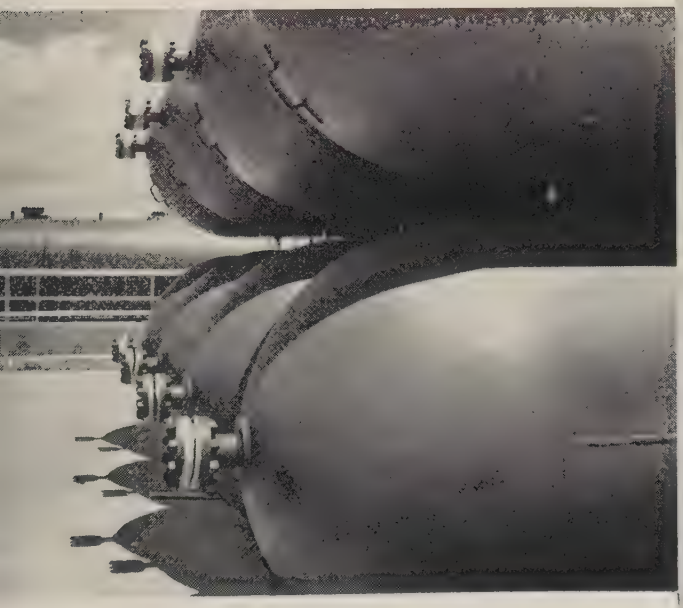
Fuel lines and process piping are Stainless and operate at pressures up to 15,000 psi. The pipe kept almost surgically clean to prevent contamin of fuel and subsequent malfunction. Vapor degrea and chemical cleaning processes are used on the p

Write in No. 112 on Reader Service Card at start of Product Preview Section

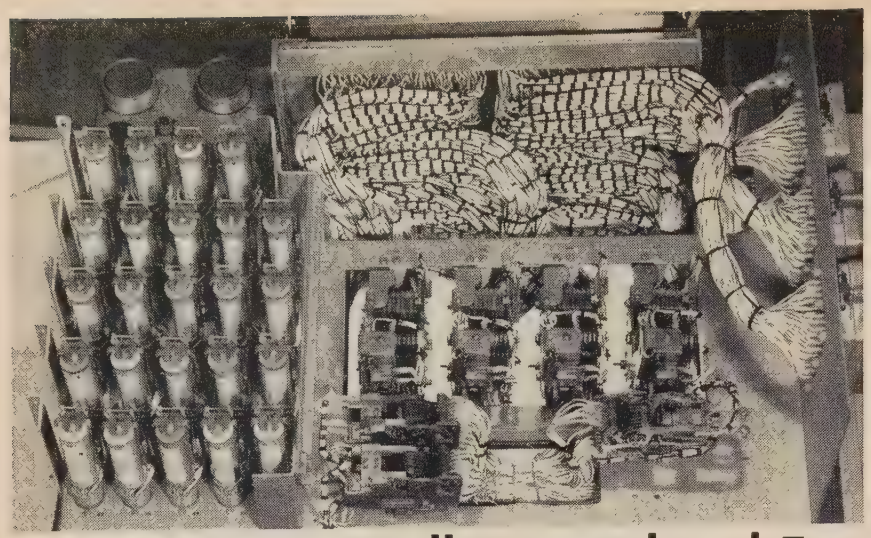
, high-strength low-alloy steel,
high-strength alloy steels, Stain-
Steel, steel fence, electrical cable,
ent or wire rope, United States
l maintains the technical services
ssist in solving any problem on
erials for ground support. When
round support program goes to
drawing board, consult with

United States Steel

USS is a registered trademark



s is powered by a cluster of liquid propellant rocket engines that
d oxygen and RP-1, a kerosene-like hydrocarbon fuel. 192 pressure
icated from alloy or Stainless Steel plate at this site store liquid
s—liquid oxygen and nitrogen and helium gases which are used to
fuels into the missiles.



NOW! Automatically Control and Test Complex Electro-Mechanical Systems

with complete reliability!

If you're having trouble testing complex electro-mechanical systems, it will pay you to investigate DIT-MCO's 250F2M Electro-Mechanical Systems Analyzer. It is specially designed to control and test integrated devices and their associated wiring by simulating controlling assemblies and monitoring their action.

Each of the Analyzer's 200 test positions can perform up to 36 independent switching functions. Its capacity to control complex systems, therefore, is almost unlimited. In each test position the 250F2M will:

1. Actuate all necessary resistive devices and provide termination-to-termination tests of each circuit for continuity and discontinuity.
2. Simulate conditions which allow it to operate and test each resistive device in the circuit under test.
3. Provide for visual measurement of resistive values and time delay constants where desired.
4. Provide switching capabilities which enable monitoring of circuit conditions with external detecting devices.

These capabilities make it possible to achieve extremely high standards with complex relay chassis and similar systems, thus eliminating borderline errors which can lead to malfunction under operating conditions.

The 250F2M uses DIT-MCO's exclusive Matrix Chart to put complete circuit information right in front of the operator's eyes. The machine is easy to operate, easy to interpret, easy to adapt to any test. Write today for full details.

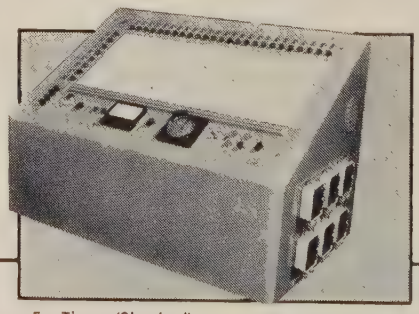
DIT MCO

ELECTRONICS DIVISION

Box 02-11, 911 Broadway
Kansas City 5, Missouri

In the Los Angeles area • Ph. ORegon 8-6106 Ph. OSborne 5-1123
In the New York City area • Ph. MUrray Hill 2-5844

Home Office Kansas City
Ph. HArrison 1-0011



SPECIFICATIONS:

1. Continuity Test
   - A. Test Voltage ..... 28 V.D.C.
   - B. Continuity Current ..... 1 ampere
   - C. Continuity Resistance ..... adjustable from 0.3 ohms to 10 ohms
2. Continuity-Discontinuity Test
   - A. Test Voltage ..... 28 V.D.C.
   - B. Continuity Current ..... 1 ampere
   - C. Continuity Resistance..0.3 ohms to 10 ohms
   - D. Discontinuity Resistance..... ....2.5 megohms reject, 3 megohms accept
3. Short Test
   - A. Test Voltage ..... 28 V.D.C.
   - B. Test Current ..... 0.03 ma (max)
   - C. Short Resistance Range ....2.5 megohms reject, 3 megohms accept
4. Ohmmeter
   - A. Range..... 0 to 200 megohms
   - B. Accuracy..... ±3%
5. Timer (Standard)
   - A. 60 minute range, 0.2 second scale division
   - B. Accuracy..0.1 sec. per operation at 60 cycles

   Timer (Optional)
   - A. 60 minute range, 0.01 second scale division
   - B. Accuracy..0.002% per operation ±1 division
6. Power Requirements
   - A. 100 to 125 V.A.C. 55 to 65 cycles (standard timer)
   - B. 100 to 125 V.A.C. 50 to 400 cycles (optional timer)
7. External Energization
   - A. 28 V.D.C. and 110 V.A.C., 60 cycles are provided for external energization of relays or other resistive devices, isolated from test voltage.
   - B. Other voltages may be supplied by external power supplies and switched as external energization or other test purposes.

Write in No. 166 on Reader Service Card at start of Product Preview Section

COAXIAL CABLES high temperatures

Designed for missile and reactor use, these frequency coaxial cables are operational to 1000° F. Resistant to direct flame, these "super-jet" cables enable electrical circuits to continue functioning after an outburst of fire, says **Boston Insulated Wire & Cable Co., Dept. S/A, 65 Bay St., Boston 25, Mass.** Other features are said to be low attentuation, gamma radiation resistance plus flexibility after exposure to high temperatures.

They find industrial use in high temperature ovens and environmental chambers, heating apparatus and wind tunnels.

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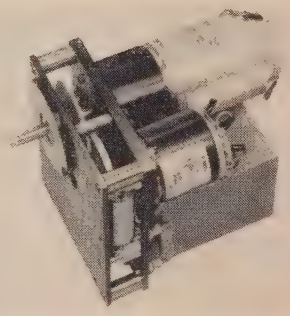
SERVO REPEATER is compact package



This precision servo repeater is designed to follow the position of a remote synchro. It operates directly from the 117v, 400 cps line, and includes servo motor, gearing, control transformer and servo amplified, says **Industrial Control Co., Dept. S/A, 805 Albin Ave., Lindenhurst, L.I., N.Y.** An output driver shaft is provided and an accurate register positions the assembly in mounting.

Top speed of the 770A is 120 rpm; maximum output torque, 30 oz-in; and stiffness, 3 oz-in/degree.

Write in No. 314 on Reader Service Card

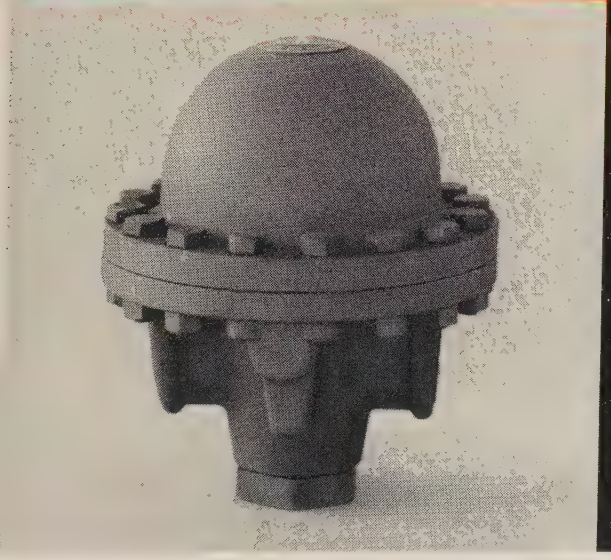
TRANSFER HOSE is chemically inert

This transfer hose is said to be chemically inert to all jet and missile fuels and oxidizers and is known as Fluoroflex-T (Teflon). The abrasion resistant rubber jacket is reinforced with a spiraled high tensile wire to prevent crush or collapse, says **Resistoflex Corp., Dept. S/A, Roseland N.J.** Fluids being transferred cannot come in contact with or be contaminated by the metal flanged fittings or outer covering, it is said.

The non-adhesive surface permits rapid flow of fluids with little or no buildup of corrosive solids.

Write in No. 315 on Reader Service Card

more on page 230



REVOLUTION IN DESIGN

Grove Regulators... As revolutionary in design and engineering as the technological transition from flying machine to space vehicle... Achieved a quarter of a century ago, the only regulators which could be used for the first missile experiments in the Navy Experimental Station at Annapolis ... still today the standard for the critical control of high pressure fluids... Now on the threshold of space, Grove is uniquely prepared—through advance research and development—to meet the challenge of even higher pressures ahead.

GROVE POWREACTOR DOME REGULATOR MODEL GH-408–50-6000 PSI INLET...5-3000 PSI REDUCED PRESSURE

GROVE VALVE and REGULATOR COMPANY

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Offices in other principal cities

Subsidiary of Walworth

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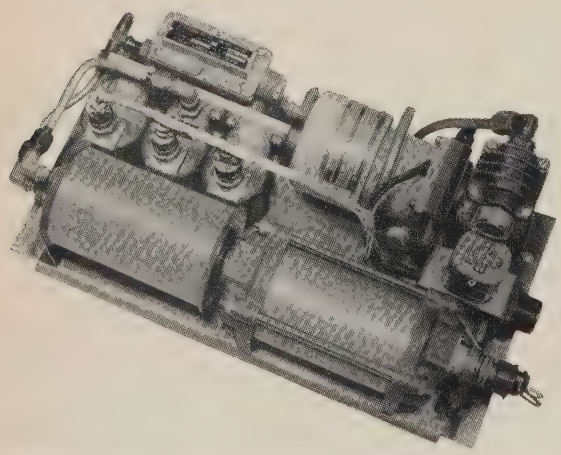
PRESSURIZATION & DEHYDRATOR UNIT

This Automatic Self-Reactivating Combination Pressurization and Dehydrator Unit completely eliminates desiccant replacement. Mechanically reliable throughout its entire life, it will not fail due to lack of desiccant maintenance. Designed to meet MIL-E-5400 and MIL-M-7969A Specs and can be applied to a variety of specific requirements for airborne, shipboard, undersea, and ground support equipment.

As a simplified compact and light weight unit it does away with electric timer and one complete dessicant chamber.

Let us show you how you can save time and money by incorporating existing units in your design plans at an early stage.



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Write today, for complete information on Great Lakes PNEUMATIC-FUEL-HYDRAULIC Components. An experienced Sales Engineer is available to discuss your requirements.

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SILVER-ZINC Battery has long "wet" stand time

This manually activated silver-zinc primary battery for missile APU power has a "wet" stand time up to 60 days, according to the manufacturers. Designated model P51A, the battery has 20 silver-zinc cells to provide 28 volts at 200 amps. Maximum current is 500 amps, and capacity is 47 amp hours. Discharge time at 200 amps is 14 min, says **Cook Batteries, Dept. S/A, 3850 Olive St., Denver, Col.** It is activated by injection of electrolyte through an outside port. The fluid reaches the battery by an umbilical tube and activation is less than 2 min.

It has a temperature range from 40 deg F. to 80 deg F. Models are available from −65 F. to 165 deg F. Thermostatically controlled heaters are included.

Write in No. 316 on Reader Service Card

MICROWAVE OSCILLATORS cover 1 1/m 18 kmc

These swept microwave oscillators cover a frequency range from 1 to 18 kmc. The series 620 offers the broadest frequency range currently available and provides electronic sweep of RF output, says **Alfred Electronics, Dept. S/A, 897 Commercial St., Palo Alto, Calif.**

All models feature linear frequency sweep coverage over all or part of each band for rapid evaluation of reflection coefficient, gain, attenuation and other network transfer characteristics. The oscillators feature two adjustable frequency markers for convenient calibration of oscilloscopes or recorders and a 0.5 microsec. rise and fall response to AM, equivalent to a 2 megacycle band pass.

Write in No. 317 on Reader Service Card

MOUNTING STUDS for accelerometers

These mounting studs fit all old and new models of series 2200 accelerometers. Constructed of two hardened stainless steel parts bonded together by a special process, these studs provide electrical isolation from structural ground, according to **Endevco Corp., Dept. S/A, 161 California Blvd., Pasadena, Calif.**

They are designated models 2980 and 2983.

Write in No. 318 on Reader Service Card

CIRCUIT BREAKER for 100-2500 deg F

This thermal circuit breaker is said to eliminate danger of open-circuiting due to current-generated heat, providing precise protection for aircraft fuel booster pump motors. Other applications include specialized electronic devices, such as telemetering equipment, computers, guided missiles and rockets, according to **Filtron Co., Dept. S/A, Flushing 55, N. Y.** Each unit weighs less than .15 oz.

It can be supplied in temperature range from 100 deg F to 2500 deg F, with a sensitivity of operation up to ±3 per cent of the rated temperature.

Write in No. 319 on Reader Service Card

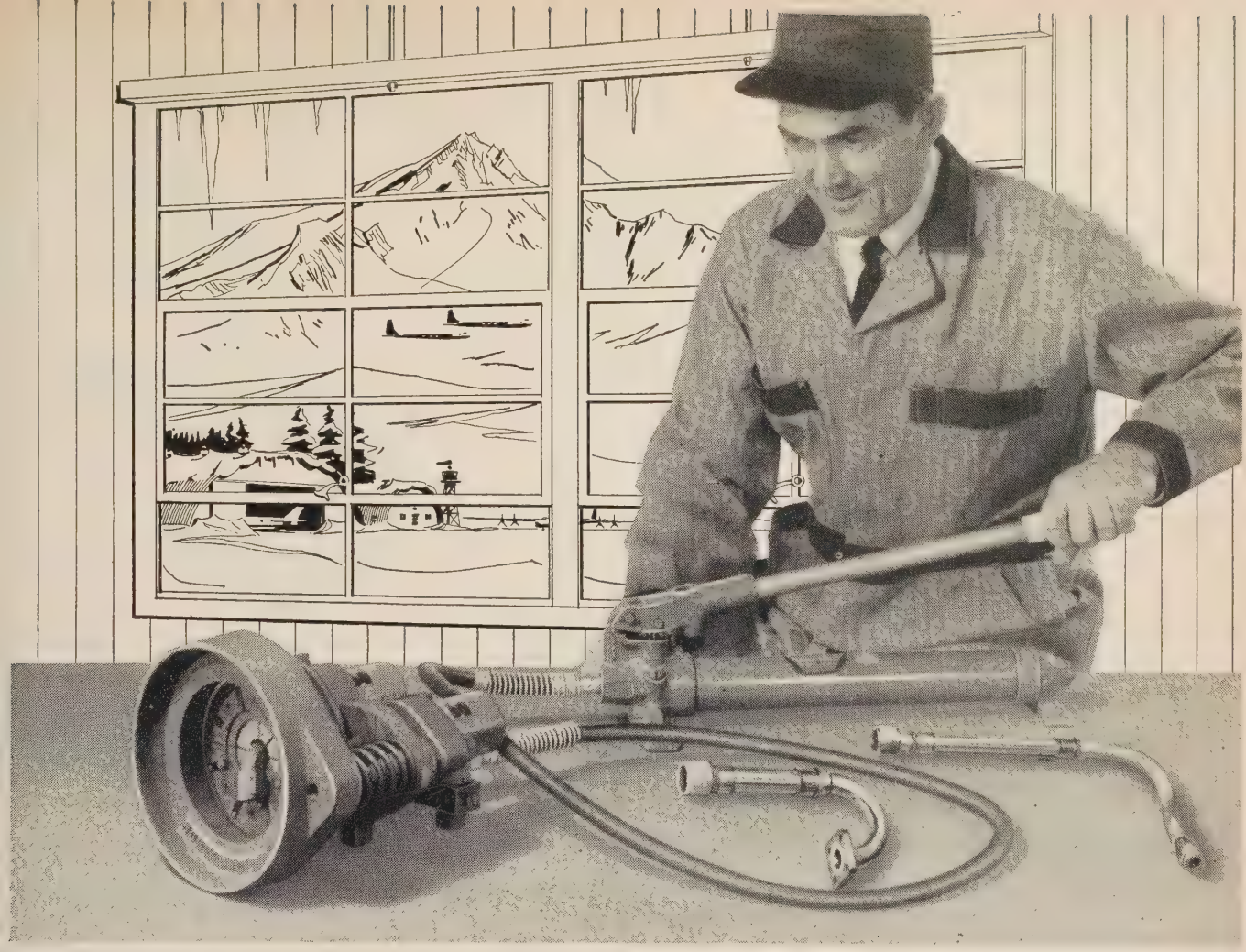
SERVO MOTOR for guidance systems

This size 5 servo motor weighs 0.6 oz and delivers .10 oz-in of stall torque. It is said to be designed to meet the severe environmental and physical requirements of air and missile borne guidance systems. Power requirements are 1.5 W per phase at 26 V, 400 cps, says **Daystrom Transicoil. Dept. S/A, Worcester, Montgomery Co., Pa.**

The units accelerate at 39,000 rad/sec/sec until the free speed of 10,000 is reached. Moment of inertia is .18 g-cm².

Write in No. 320 on Reader Service Card

more on page232



Now Available, Resistoflex Portable Swager for Field Assembly of Teflon Hose Lines

With the Resistoflex swager you can make up factory-quality Fluoroflex-T hose assemblies anywhere!

The Resistoflex swaged fitting used with Fluoroflex®-T (Teflon®) is the standard of the industry, and is without equal for reliability.

Now an advanced swaging machine developed by Resistoflex enables you to manufacture Fluoroflex-T hose assemblies, with the proper fittings, anywhere needed. The Resistoflex swager needs no special skill to operate, yet it turns out consistently reliable, leak-proof, blowoff-proof, tamper-proof assemblies. It handles fittings for high as well as medium pressures, in straight, elbow, and all special configurations.

If you need field assembly facility for Teflon hose lines, it will pay you to look into this practical, useful new machine. For full details, just write to Resistoflex Corporation, Roseland, N. J.

®Fluoroflex is a Resistoflex trademark, reg. U.S. Pat. Off.
®Teflon is DuPont's trademark for TFE fluorocarbon resins.

ORIGINATORS OF FLUOROCARBON HOSE ASSEMBLIES

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CORPORATION

COMPONENTS FOR HIGH-TEMPERATURE AND CORROSIVE SERVICES

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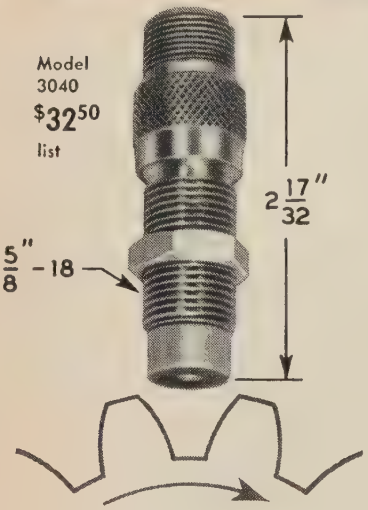
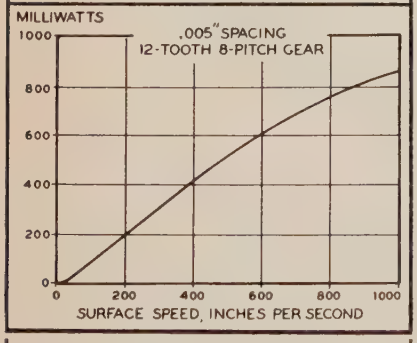
SELF-POWERED MAGNETIC PICKUP



Over-Speed Protection WITHOUT Amplification

SELF-GENERATING
. . . NO CONTACT
WITH EXCITING GEAR

Output vs. surface speed
(1250 ohms resistive load)



Physical specifications may be altered to meet your space limitations.

Also specially designed transducers for:

- metering liquid rocket fuel
- measuring speed of turbines
- generating frequency in drones.

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ELECTRO PRODUCTS LABORATORIES

Sensing Elements for Control
Counting
Speed and Displacement Measurements

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Canada: Atlas Radio Ltd., Toronto

9012

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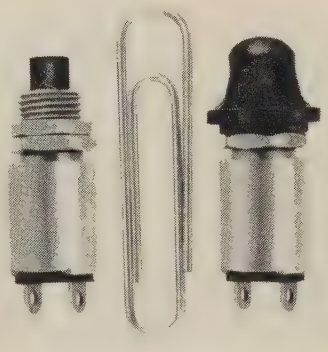
CUSTOM CABLES for missile use

These custom electrical and electronic cable and cable assemblies are designed for aircraft and missile use and can be manufactured to nearly any length or size. Cables are manufactured on special planetary cabling machines, says **Robertshaw-Fulton Controls Co., Dept. S/A, 911 E. Broad St., Richmond 19, Va.** Umbilical cables using fiberglass strands as fill and strain members to achieve tensile strengths equivalent to steel are said to be a recent development.

Write in No. 321 on Reader Service Card

SNAP SWITCH in aluminum case



This push-button, snap action, miniature switch is housed in an anodized aluminum case. Mounting by means of a ¼-40 threaded bushing the switches has a diameter of 11/32 and overall length of 1 1/64 in, according to **Hetherington, Inc., Dept. S/A, 1420 Delmar Dr., Folcroft, Pa.**

It handles 2 amps. at 28v dc or 120v ac with a life of 25,000 operations minimum.

Write in No. 322 on Reader Service Card

RATE GYROS for precise measurements

Precise angular rate measurements may be obtained from these miniature, fluid-filled rate gyros despite the extreme shock and vibration of missile environments, says **Kearfott Co., Inc., Dept. S/A, 1500 Main Ave., Clifton, N.J.** Fluid-filling, besides reducing shock and vibration effects, cuts bearing friction in ac types and potentiometer wiper friction in dc types.

The gyros operate over a −65 to +185 deg F range, and they require only 30 sec for warm up. Advantages include the elimination of accessory heaters, interchangeability of all but ten per cent of the parts, and light weight. The A2015 units are for ac pick-offs and B2015 for dc pick-offs.

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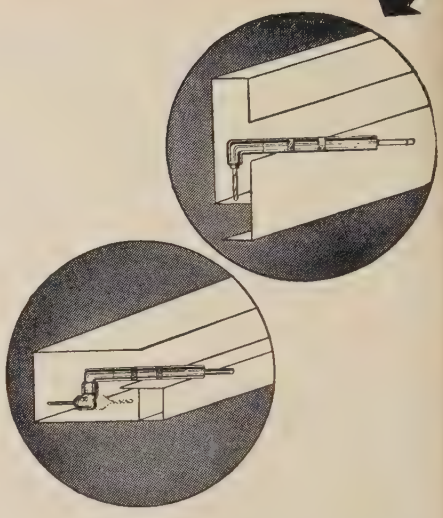
more on page 234

. . . FOR THESE ANGLE DRILLING APPLICATIONS



● AND MANY MORE . . . there is a TERRY Angle or Flexible Tool to fill your needs.

TERRY Angle Drilling Attachments

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Superb accommodations, full value and "snap-to" service

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Laguna Beach, Calif.
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GRaystone 4-3600 in San Francisco
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MAin 3-6688 in Seattle
or Teletype LA 1840 in Los Angeles

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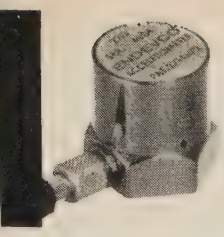


FORD VIBRATION INSTRUMENTATION: The Ford Motor Company entered the experimental gas turbine engine field in 1952. The Ford Turbo Machines Department is now engaged in research and development of a turbine engine and a working model has been tested in a tilt-cab truck. An obsolete engine, the Ford 702, has developed 160 horsepower at shaft speeds up to 36,000 rpm. ■ A new supercharged 300 horsepower turbine engine was recently announced by Ford Engineers. Known as the "704," the engine weighs 650 pounds installed, compared to 2,700 pounds for a truck diesel engine of comparable horse-

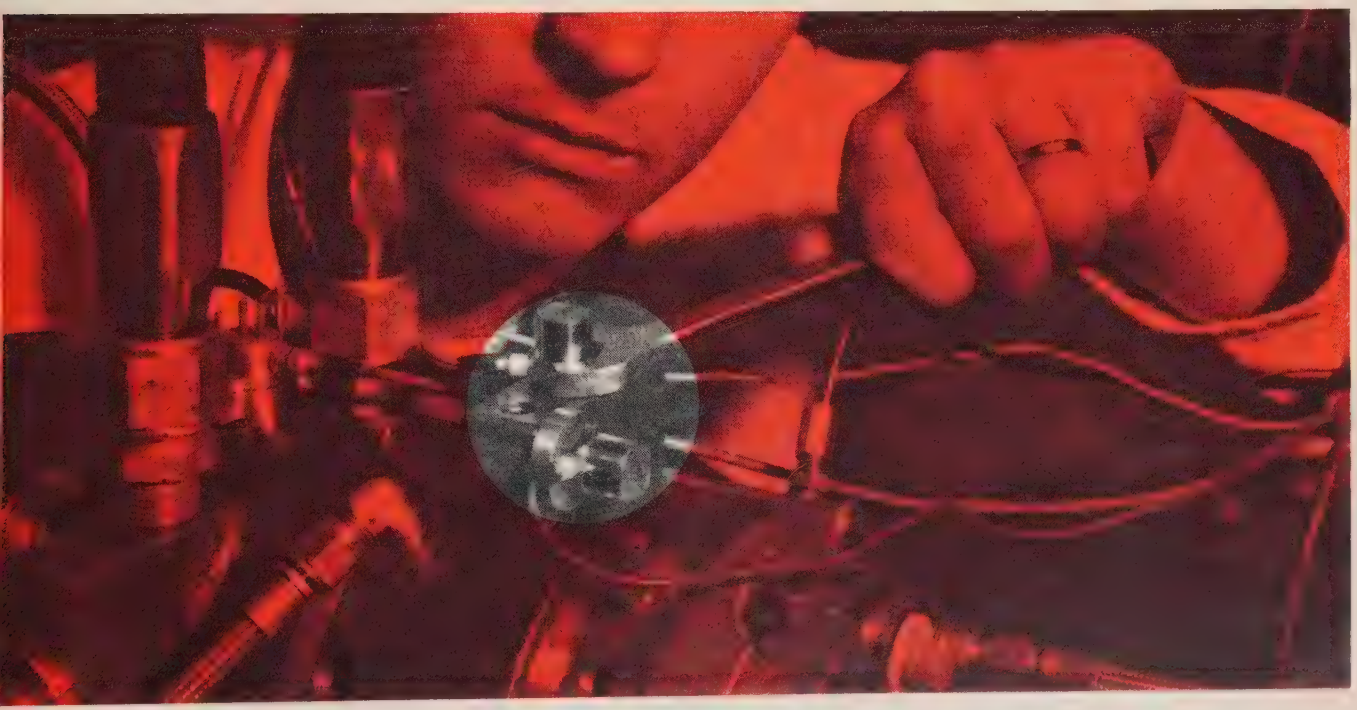
ENDEVCO TRANSDUCERS SOLVE VIBRATION ANALYSIS PROBLEM

power. The engine has two stages of compression, each operating at a 4:1 pressure ratio. Two burners are used for driving the dual compressors, the low speed wheel turning at 46,500 rpm and the high speed wheel at 91,500 rpm.

THE PROBLEM: The Ford Test program requires a wide variety of instruments to measure, control and record performance data of component parts. Measurement of vibration, for example, is a critical factor in this program. Vibrations that may cause metal fatigue, oil film breakdown, overheating, etc., are discovered during tests on individual engine "stands."

THE SOLUTION: Ford engineers use a total of six Endevco Series 2200 Accelerometers providing frequency responses up to 6,500 cycles per second. The accelerometers are connected to bearing test rigs, for example (see photo). The accelerometers relay measurements of acceleration movements in turbine shafts from three coordinates (radial vertical, radial horizontal and axial). Temperatures of the metal housings to which the standard Endevco transducers are attached average up to +150°F. Temperatures at which the water-cooled, heat-resistant models are used range up to +1000°F or more. The large self-generated output of the Endevco accelerometers eliminates the need for additional stabilization of a power supply.

THE RESULTS: The Endevco transducers are attached with a single-pole threaded bolt. The signal is fed through an Endevco amplifier to an oscilloscope or panoramic analyzer. The analyzer concentrates on a small section of the total signal and may present from 4 to 10 harmonic vibrations of different frequencies being fed from the unit at one time. This analyzer separates the frequency bands into individual bands, which it then sweeps from 20 to 40,000 cycles every second, measuring the frequency and amplitude in millivolts. ■ Ford Technicians convert these vibration records by mathematically integrating acceleration with respect to time to obtain the displacement or housing vibration. Thus, they locate the sources of objectionable resonance and take steps to eliminate or reduce vibration in the overall design. ■ Endevco accelerometers have also served as pickups for determining spring rate and damping characteristics of rubber bonded bearings. • **ENDEVCO CORPORATION** • 161 EAST CALIFORNIA BOULEVARD PASADENA, CALIFORNIA • PHONE SYCAMORE 5-0271



Close-up shows two Endevco Accelerometers on bearing test rig in Ford Instrumentation Section, Dearborn, Michigan. Cable passes to Endevco Amplifier (not shown on right).

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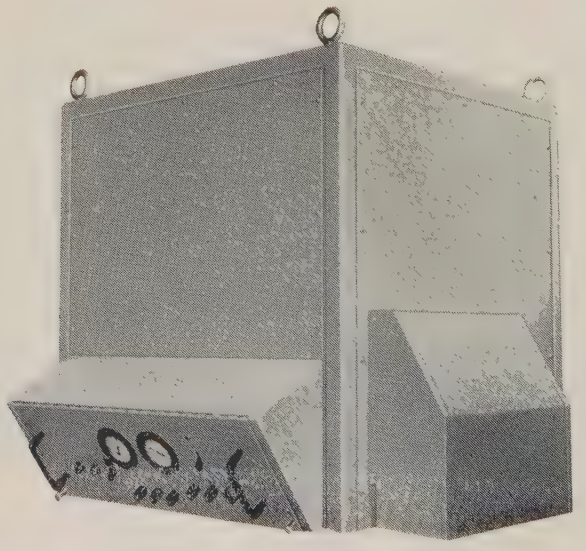
SOLVED...A RELIABLE ENVIRONMENT FOR TEMPERATURE-SENSITIVE EQUIPMENT. This Budd Lewyt equipment keeps sophisticated electronic systems 'calm', cool, and reliable under varying ambient conditions. Operation is completely automatic over the full ambient temperature range (+14°F to +125°F) holding the control temperature to ±2°F of the selected setting. The unit is compact, measuring only 30"x 28"x 26". Ask for engineering data sheet HAC-1000, write Environmental Control Section, Dept. 22, Budd Lewyt Electronics, Inc., Long Island City 1, N. Y.

BUDD LEWYT *A SUBSIDIARY OF THE Budd COMPANY*
HEAT EXCHANGERS ☐ AIR CONDITIONERS ☐ PRESSURIZERS
DEHYDRATORS FOR GROUND, SHIPBOARD & SPACE APPLICATIONS



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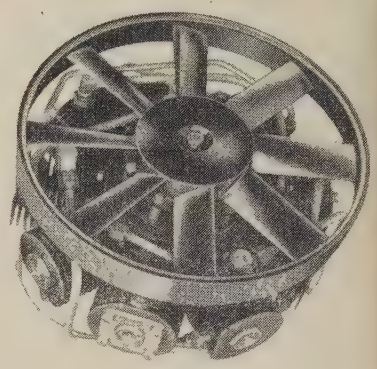
COMPRESSOR SYSTEM for high temperature



This high-temperature pneumatic system compressor, designed for extreme environments, is a 9-cylinder, 3-stage radial type, designated model 309. It is said to be efficient at high temperatures because of the size of the cooling fin area, according to the **Cornelius Co., Aero Div., Dept. S/A, 550 39th Ave., N. E., Minneapolis, Minn.** It carries a 12 in 8-blade airfoil design fan with a 1,000 cfm flow capacity.

Model 309 is for fuel air starting systems, emergency pneumatic systems, air retrolaunch systems, air ejection systems, and air sampling. It has a dry weight of 28.25 lb, is equipped with hydraulic motor, and can be used with ground support equipment.

Write in No. 324 on Reader Service Card

FLOW REGULATOR for fuels and oils

This regulator is designed to provide a constant flow rate of 1.7 gpm ±3 per cent regardless of differential pressures from 10 to 2000 psi. In ⅜ in line size, .25 lb, this unit will handle operating pressures to 3000 psi; proof pressures to 4500 psi, says **Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa.** It operates in the temperature range of −65 deg F to +350 deg F.

The valve, No. 45-2020-000, can be manufactured in other line sizes to handle a variety of flow volumes, and, can be modified for tight flow tolerances, other differential ranges, and temperatures to 700 deg F.

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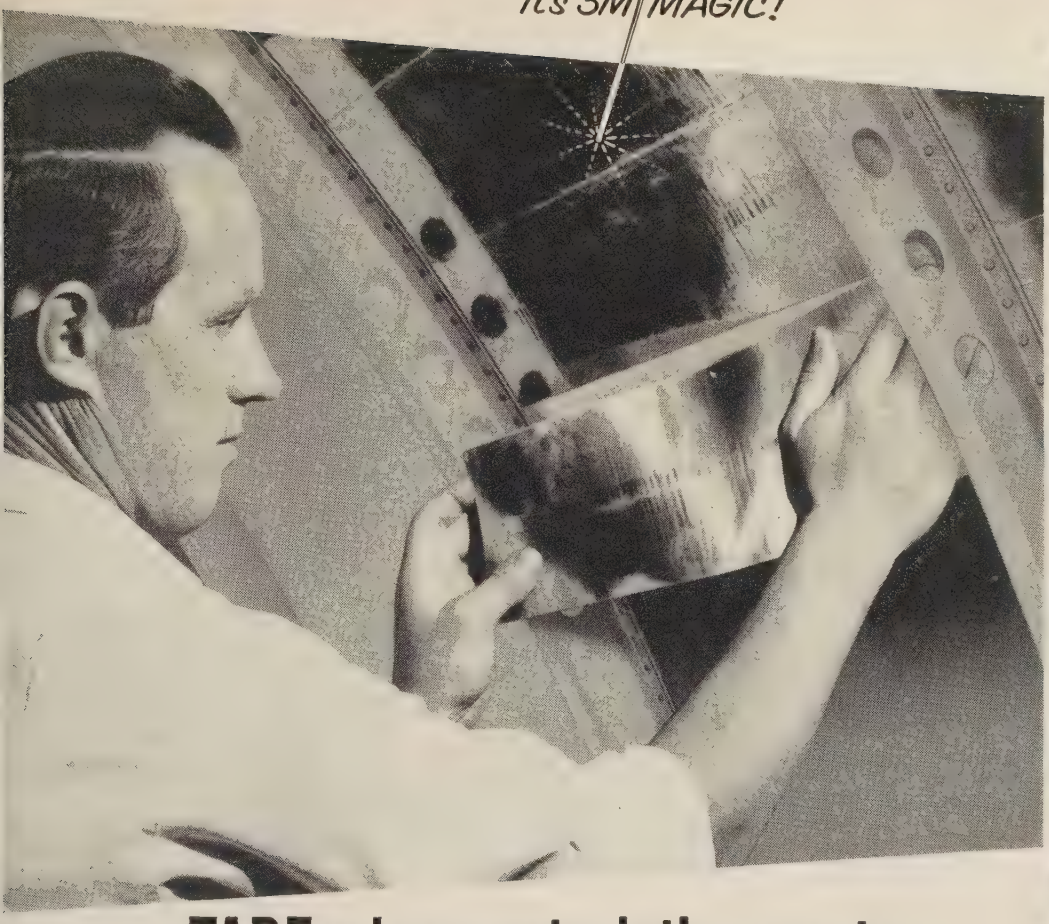
more on page 236

It's 3M MAGIC!



TAPEnology cuts jet's roar to hushed whisper

When Convair's new 880 "Jet-Liners" go into scheduled airline service, passengers will notice an increased "quiet" in flying: the high frequency noises of the boundary-layer effect and the exhaust from the four powerful General Electric CJ-805 turbo-jet engines—somewhat suppressed by extra-thick fuselage skins—will be further hushed to a soft whisper inside the cabin by a newly developed "SCOTCH" Brand Tape.

More than 1¼ miles of this tape—"SCOTCH" Brand No. 428 Sound Damping Tape—is applied directly to inside of fuselage panels throughout the "880". A specially developed visco-elastic adhesive between the tape backing and the skin panel reduces metal vibration by converting sound energy into heat energy. This changes the natural frequency of the panel and provides sound damping beyond that possible by adding only mass or stiffness to the aluminum. One person can do the entire application if necessary . . . weight control is precise throughout. Results? "Beyond expectations of acoustic engineers" says Convair.

Want to know more? Ask your nearest "SCOTCH" Brand Tape distributor, or write: 3M Co., 900 Bush Ave., St. Paul 6, Minn., Dept. IAO-20.

When tape costs so little, why take less than "SCOTCH" Brand?

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3M's Missile Industry Liaison translates your problems to 3M specialists in your field of interest. Write for free brochure

"SCOTCH" is a registered trademark for the pressure-sensitive adhesive tapes of 3M Co., St. Paul 6, Minn. Export: 99 Park Ave., New York 16. Canada: London, Ontario.

MINNESOTA MINING AND MANUFACTURING COMPANY
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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SUPERIOR ACCURACY

in heat controls

for jet windshields

Convair 880 jet airliners are first to use new, advanced design anti-fogging, anti-icing heat control systems developed by Magnetic Controls Company.

Windshield icing and fogging problems are considerably more complex for jet airliners, compared with those encountered by piston engine planes. With jet travel, faster speeds, higher altitudes, plus greater extremes in temperatures and atmospheric pressures, many new problems develop. Magnetic Controls proportional heat control systems have helped to solve these problems for Convair 880 jets. The Magnetic Controls systems offer four distinct advantages:

- **Automatic compensation for windshield aging.**
- **Ultra-reliable, fully static design.**
- **Elimination of thermal shock for longer windshield life.**
- **Superior accuracy — proportional plus integral control.**

For complete information about this system and how it may help you obtain precise, accurate heat control for many applications, write or phone Magnetic Controls Company today.

MAGNETIC CONTROLS COMPANY

6409 CAMBRIDGE STREET • MINNEAPOLIS 26, MINN. • WEst 9-4691

Heat Control Systems • Static Inverters • Voltage Monitoring Systems

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MINIATURE TAPE HEAD has 4 channels

Model 15-4X, four channel head, designed primarily for flight use in miniature tape recorders, features precision machined all metal construction with individual tracks shielded magnetically and electrostatically, says **J. B. Rea Co., Inc., Electronics Div., Dept. S/A, 2202 Broadway, Santa Monica, Calif.**

Gap alignment is precision machined and optically lapped. Specifications and number of tracks may be varied to meet requirements. Overall dimension are 0.608 in h. by 0.600 in w. by 980 in d.

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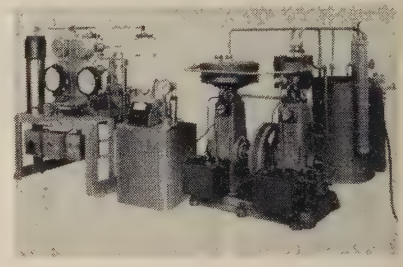
PRESSURE SYSTEM super-dries fuels



This high-pressure gas-drying system is constructed primarily for missile ground-support installations and other super-drying applications. It contains 3 basic units: drier, hygrometer moisture indicator, and Corbin diaphragm-type compressor, says **American Instrument Co., Inc., Dept. S/A, 8030 Georgia Ave., Silver Spring Md.** It can be mounted on a common base, or as separate components.

It is an automatic dual-assembly, one side furnishes super-dry gas; the other undergoes reactivation. The drying chambers use "molecular sieve," said to be capable of drying and delivering gas for months without replacement to dew-points as low as minus 100 deg F.

Write in No. 327 on Reader Service Card

TWIN-TRIODE TUBE for low level input voltage

This 9 pin miniature twin-triode tube WL7025 designed for service as a low level input voltage amplifier for tape recorders and high quality audio preamplifiers. The tube is interchangeable with tube 12 A X7, 12 DX 7 and ECC83, says **Westinghouse Electric Corp., Box 2278, Pittsburgh, Pa.**

Use of the tube in such circuits will result in substantial reduction noise due to microphonism, induced hum and leakage. The new tube uses a v-shaped spiral heater which can withstand extremely high voltage surges.

Write in No. 328 on Reader Service Card

more on page 238

Experience—*the added alloy in* **Allegheny Stainless**

HIGH TEMPERATURE ALLOYS YOU CAN WELD OR BRAZE LIKE STAINLESS

n addition to their high strength characteristics, AM 350 nd AM 355, A-L's precipitation hardening stainless steels, ave other advantages for designers of missiles and super-onic aircraft.

When welding AM 350 and AM 355, there is little or no endency to hot cracking or poor weld ductility, even in eavy sections. Both alloys weld as easily as the common tainless steels, even in the completely heat-treated condi-ion. Brazability is equally easy—no special surface prepara-ion is required during brazing operations.

Due to the high ductility in the annealed condition both lloys lend themselves to various kinds of fabrication—they an be spun, machined or formed using normal procedures.

In the heat-treated conditions, AM 350 and AM 355 have remarkable strength-to-weight ratio at both room and elevated temperatures, retaining useful strength and ductility up to 1000 F.

AM 350 is available commercially in sheet, strip, foil, small bars and wire. AM 355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars, wire, sheet and strip.

For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355." *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

862

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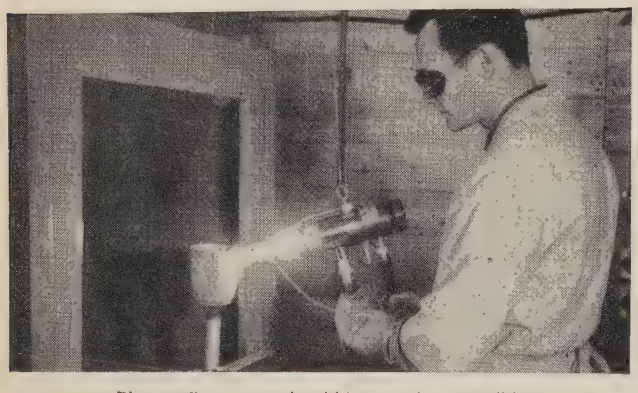
Apply coatings of high melting point materials such as tungsten, tungsten carbide, molybdenum, chromium carbide, titanium oxides, calcium zirconate, rare earth oxides. Operates at 10,000°-15,000°F.



Plasma flame spraying hi-temperature crucible

Now any material that can be melted without decomposing can be sprayed. Despite high melting temperature, object sprayed stays cool.

High fluidity of particles and high velocity of impingement bond the particles together to produce high density coatings semi-fused to work. Absence of air eliminates oxidation.

The METCO Plasma Flame Spray Gun is a valuable new tool for the metalworking research department or production line. Operates on inexpensive inert gases with high electrical power conversion efficiency, long component life. Continuous gas streams, as high as 30,000°F., with accurate control of temperature, generated at costs of ⅓ to ½ those of oxygen-fuel gas equipment for equivalent heat output. No combustion—uses inert gases. No flashback or explosion hazards—push-button operation.

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Flame Spray Equipment and Supplies
1133 Prospect Avenue, Westbury, Long Island, N. Y.
In Great Britain METALLIZING EQUIPMENT CO., Ltd.
Chobham-near-Woking, England

Please send me free bulletin on the Metco Plasma Flame Spray Gun.

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____

Write in No. 178 on Reader Service Card

HYDRAULIC VALVES are pressure-controlled

This 3000 psi pressure controlled hydraulic valve for such functions in a hydraulic circuit as relief, sequence, unloading, reducing, and counterbalances is known as series 8800. It has the ability to obtain from a single basic valve assembly any one of the above functions, says **Rivett, Inc., Dept. S./A., Brighton 35, Boston, Mass.** Full pressure rating can be obtained in all units at the point of valve opening.

Three basic sizes are available according to desired capacity.

Write in No. 329 on Reader Service Card

TRANSDUCER for severe environments

A precision pressure transducer designed to measure gage or absolute pressures in the 100-10,000 psi range and give high performance under severe environmental conditions has been announced by **Fairchild Controls Corp., Components Div., Dept. S/A, 225 Park Ave., Hicksville, N. Y.** Model TPH-175 is a dynamically balanced pressure transducer which uses a twin spring linkage to eliminate pivots or bearings which eliminates friction points, it is said.

Overall accuracy including linearity, friction and hysteresis is ±2 per cent with resolution as low as 0.25 per cent.

Write in No. 330 on Reader Service Card

ENVIRONMENTAL PLUG has sealing grommet

This environmental resistant plug uses a moisture sealing grommet at the exit of the wires which seals each wire individually and also supports the cable. Advantages of the new MS-R are said to be a 30 per cent saving in length and 25 per cent in weight, according to **Cannon Electric Co., Dept., S/A, P. O. Box 3765, Terminal Annex, Los Angeles 54, Calif.** The MS-E series will continue to be furnished for replacement purposes, although this class "R" plug supersedes them, according to the specifications MIL-C-5015.

The MS-E types may continue to be used in existing equipment, it is said, but are not to be incorporated in newly designed equipment.

Write in No. 331 on Reader Service Card

POTENTIOMETER for internal mounting

This ½-in linear motion potentiometer with a temperature range from —65 deg to 275 deg is used to measure displacement of missile and aircraft actuators and can be used as single or double potentiometer output, says **Servonic Instruments, Inc., Dept. S/A, 640 Terminal Way, Costa Mesa, Calif.** It is capable of withstanding vibration to 35 G, critical elements of the model G-76 are isolated and oil sealed within a high-strength alloy case.

Specifications include: ranges, ⅛ in to 12 in; linearity, .5 per cent of full range; overall length, 1⅞+ travel. The unit meets MIL-E-5272-A for sand, dust, humidity, etc.

Write in No. 332 on Reader Service Card

DELAY LINES withstand severe environments

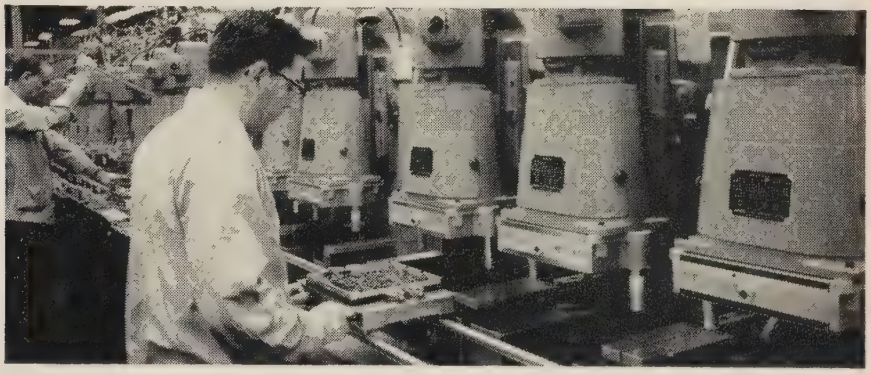
The Model 31-6 has a time delay of 3 microsec. and a delay-rise time ratio of 15/1 with a characteristic impedance of 1200 ohms., says **ESC Corp. Dept. S/A, 534 Bergen Boulevard, Palisades Park, N. J.** It operates in a temperature range of from —55 deg C to 125 deg C. Dimensions are 3x1x1 in.

Write in No. 333 on Reader Service Card

more on page 240

TECHNICAL KNOWLEDGE + EXPERIENCED MANAGEMENT + SPECIALIZED CRAFTSMANSHIP = **KNOWMANSHIP**

Knowmanship makes the difference



The technical knowledge that's part of Eclipse-Pioneer's KNOWMANSHIP can work for prime contractors in two important ways. First, as a potent helper in getting the contract. Second, as a positive time- and money-saver in fulfilling that contract.

Take just one "plus" that results from our technical knowledge in the area of production capabilities. By making some Bendix-patented modifications to our battery of Steinel precision boring machines, we have tailored them to our special type of high-precision mass production. Result: We can now bore 136-hole pieces *without limitation on center distances, to 0. 0002" hole and location tolerances and to bore size limits of* $\pm\frac{.0002"}{.000"}$ *in an average time of ten minutes, with no scrap.*

This is typical of the kind of performance that accrues to "primes" with E-P KNOWMANSHIP on their teams. And it is typical of why we are able to design and build better, lower cost, and more accurate sub-systems for modern weapons. Isn't this exactly the kind of ingenuity and creativity you want on *your* contracting team? Call, wire, or write for the full KNOWMANSHIP story as it applies to any of the product areas listed below.

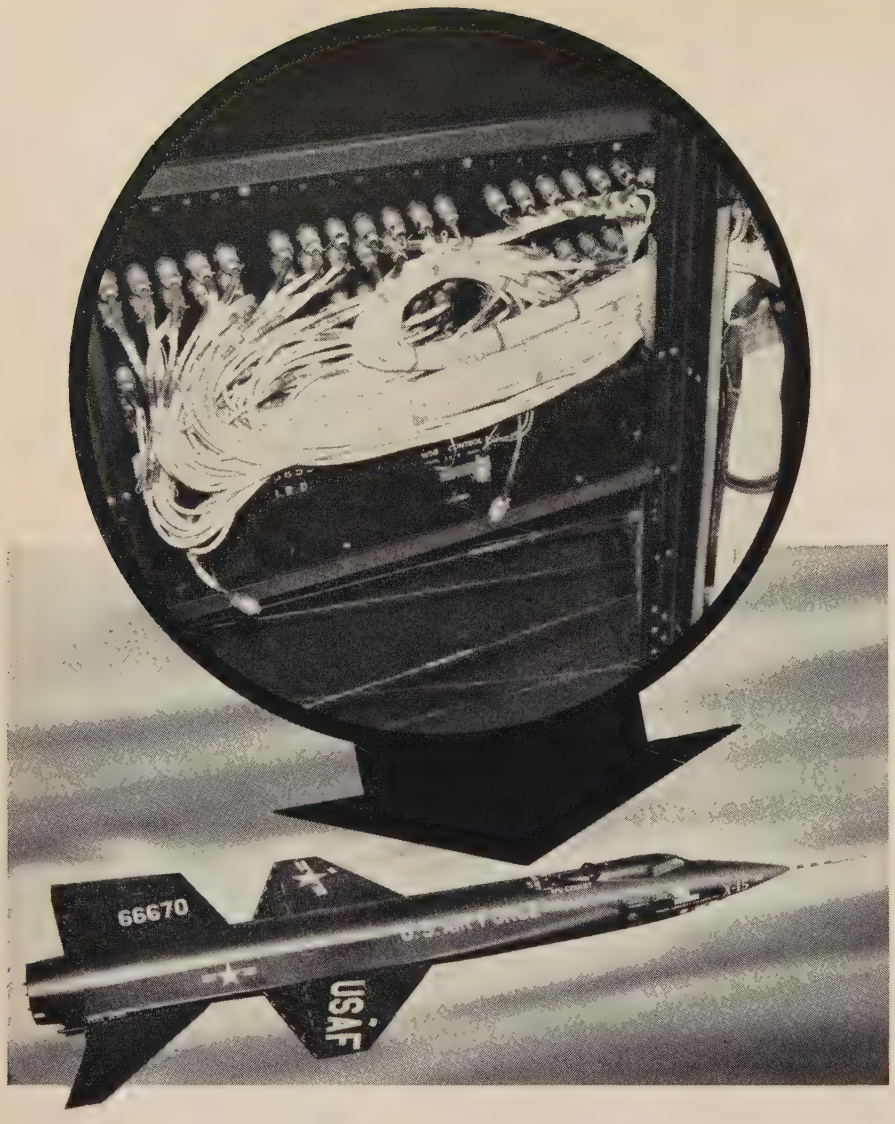
69% of E-P's procurement dollars go to small business.

ECLIPSE-PIONEER

TETERBORO, N. J. DIVISION of Bendix AVIATION CORPORATION

AUTOMATIC FLIGHT CONTROL • CENTRAL AIR DATA SYSTEMS • SPECIALIZED INSTRUMENTATION • NAVIGATION COMPUTERS AND DIRECTORS
STABLE PLATFORMS • INERTIAL GUIDANCE • RADAR ANTENNA STABILIZATION AND TRACKING SYSTEMS • GROUND SUPPORT EQUIPMENT

Write in No. 179 on Reader Service Card at start of Product Preview Section



Tensolite Cable Rides the X-15

It's no small honor to be picked to ride the X-15—America's first space-craft. All components were carefully selected, then checked and re-checked for top performance and reliability. Tensolite is honored to have its multi-conductor cable included in this tremendous program.

Producing inherently reliable Teflon® cable and cable assemblies is Tensolite's specialty. Cables utilizing the maximum number of conductors in a minimum of area—saving weight and space—are available as ribbon cable or standard round configurations.

"You write the specs—Tensolite does the rest." Or let our experienced cable design engineers assist you. Many leading aircraft and electronic manufacturers are taking advantage of Tensolite's new, expanded design and production facilities in the cable field. We'd like to work with you on your high temperature cabling problems. Contact your local Tensolite representative, or write to:

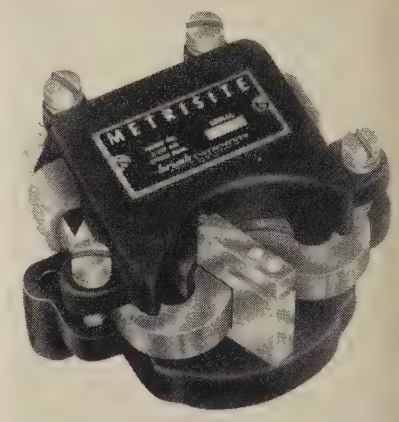
Tensolite INSULATED WIRE CO., INC.
A Subsidiary of Carlisle Corporation
West Main Street, Tarrytown, N.Y.
Pacific Division: 1516 N. Gardner St., Los Angeles, California

HOOK-UP WIRE • AIRFRAME WIRE • COAXIAL CABLE • MULTI-CONDUCTOR CABLE • MAGNET WIRE

® Du Pont

Write in No. 180 on Reader Service Card at start of Product Preview Section

TRANSDUCER has high resolution



This motion sensing device, known as Metrisite, is essentially a type of transducer with a unique combination of desired performance characteristics. This unusual combination of properties includes extreme resolution, minute operating force, very accurate linearity, high stable output, wide range of possible configurations, and exceptional ruggedness, according to **Clevite Corp., Brush Instruments Div., Dept. S/A, 37th & Perkins, Cleveland 14, Ohio.**

Resolution is such that measurements as small as one ten-millionth of an inch can be made with ease. The limit of resolution is dependent only on the mechanical system with which it is used. True linearity is achieved from 0 to full range due to the absence of hysteresis loss. Production models have a proven linearity of 1/10 per cent.

Write in No. 334 on Reader Service Card

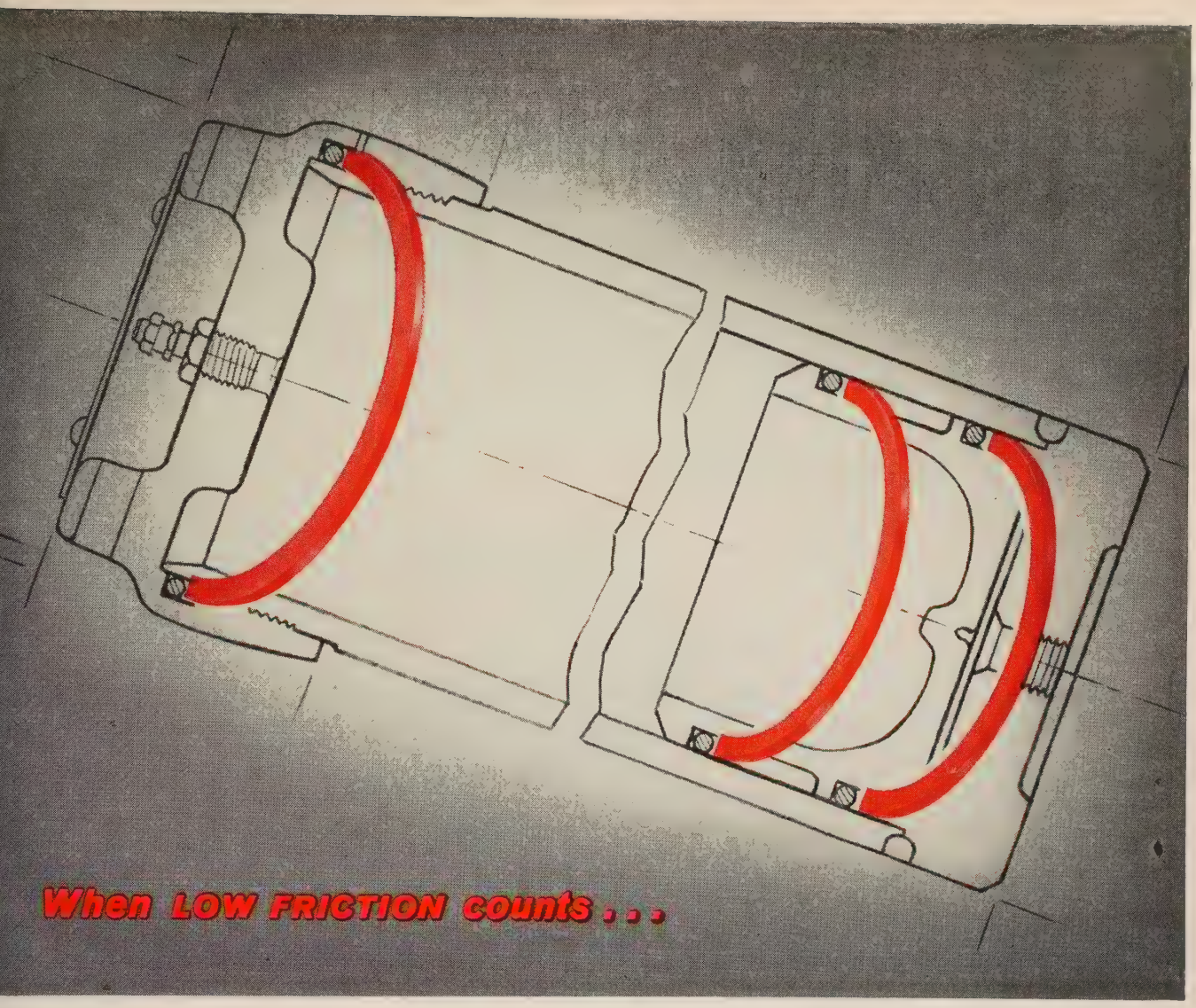
SERVO VALVE is hydraulic

This model 415 hydraulic servovalve first and second stages can receive and pass on particles as large as 200 microns without malfunction; the first stage hydraulic preamplifier has only one oil source, preventing it from becoming unbalanced from contamination, says **Raymond Atchley, Inc., Dept. S/A, 2340 Sawtelle Blvd., Los Angeles 64, Calif.** It has a frictionless high gain push-pull force feedback servo that controls the second stage.

The hermetically sealed torque motor is "dry," isolated from the hydraulic fluid. It has a low hysteresis of less than 2 per cent; resolution, 0.1 per cent. Maximum flow is 10 GPM with 1000 psi drop. Operating pressures from 300 to 4500 psi. Weight 13 oz.

Write in No. 335 on Reader Service Card

more on page 242



Look for back-up rings of TFE resins

To reduce frictional drag to a minimum and to prolong the life of O-rings, three back-up rings of TEFLON TFE resins are used in the accumulator of a hydraulic cranking system (shown above). The accumulator operates at pressures up to 3,000 p.s.i. and the back-up rings of TEFLON TFE resins prevent the extrusion of the relatively soft O-rings. In operation, some of the TEFLON TFE resin is deposited on the O-rings as they move about the groove, further reducing friction drag.

The exceptionally low static coefficient of friction of TFE resins—only 0.04—is one of the reasons why back-up rings made of TFE resins help assure efficient, trouble-free performance in any application. They provide longer life, safer and more reliable operation and reduced maintenance problems in everyday seal designs, as well as in applications that involve adverse conditions, like temperature extremes or corrosive problems.

When considering the time spent in the design, manufacture and installation of seals for use in aviation products and production, it is sound economic practice to put a quality material at the heart of the seal. Find out more about the unique advantages offered by TFE-fluorocarbon resins in back-up rings and in all types of seals. For product and design information consult your local supplier. Look for him under "Plastics—Du Pont" in the Yellow Pages, or write to: E. I. du Pont de Nemours & Co. (Inc.), Advertising Department, Room T-62, Nemours Bldg., Wilmington 98, Delaware.

In Canada: Du Pont of Canada Ltd., P. O. Box 660 Montreal, Que.

DU PONT® TEFLON®

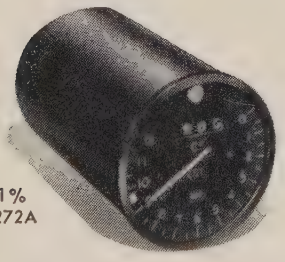
TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

Write in No. 181 on Reader Service Card at start of Product Preview Section

...now taking Lockheed ELECTRA'S *temperature...to 1°C.*



Accuracy 0.1%
Meets MIL-5272A

High accuracy, and easiest *needle pointer plus digital in-line counter readout,* are the principal service features of the BH183 AUTOTEMP™ jet engine temperature indicator.

AUTOTEMP® is designed and produced by the makers of the JETCAL Analyzer®, the only jet engine tester used throughout the world.

The AUTOTEMP is a completely new instrument...a continuous null balance 144-inch slidewire potentiometer combined with a linearizing analog-to-digital converter. Its accuracy is the simple attribute or phenomenon of its novel and basic slidewire potentiometer!

Self-contained...silicon-transistorized, miniaturized, hermetically sealed, servo-driven...the AUTOTEMP'S 3"-diameter case includes a Zener reference, power supply, amplifier, servo motor, cold junction compensation and the 144-inch slidewire and punched tape to linearize thermocouple e.m.f. for exact, counter-type digital readout. The needle pointer indicates in 50°C increments over the 0 to 1200°C full range of the unit.

Full information is contained in our Bulletin BH183 available for the asking!

B & H INSTRUMENT CO., INC.
3479 West Vickery Blvd. • Fort Worth 7, Texas

Sales-Engineering Offices:
ATLANTA, GA., COMPTON, CAL., DAYTON, OHIO., VALLEY STREAM, L.I., N.Y., WICHITA, KAN., TORONTO, ONT. *(George Kelk Ltd.)* MITCHAM, SURREY, ENGLAND *(Bryans Aeroquipment Ltd.)*

Write in No. 182 on Reader Service Card at start of Product Preview Section

SELECTOR VALVE *for liquid oxygen*

This ball valve of segmented ball design handles LOX at −300 deg F under ambient conditions from −30 deg F to 160 deg F. Main line size is 4 in. Bypass line size is 2½ in. Operating pressure for the valve is 1100 psig, according to **Koehler Aircraft Products Co., Dept. S/A, 409 Leo St., Dayton, Ohio.** Actuation from full-open to full-closed is 35 milliseconds by the explosive squib method.

Physical dimensions of the 4 in line size valve are 24⅞ in long x 9½ in deep. Weight is 50 lbs.

Write in No. 336 on Reader Service Card

TOGGLE SWITCH *is subminiature*

This precision ultra subminiature DPSt toggle switch, identified as T4301, controls currents in the range of milliamperes and is housed in a cadmium plated brass case. It has an overall length of 29/32, is 11/32 sq and weighs .006 lbs, says **Hetherington, Inc., Dept. S/A, 1420 Delmar Dr., Folcroft, Pa.** Four 10 in long leads, two white, two red, to denote individual circuits, are connected to the terminals and protected by the potted base.

A silicone rubber boot can be supplied to cap the toggle for additional protection against moisture.

Write in No. 337 on Reader Service Card

OSCILLOSCOPE CAMERA *for continuous viewing*

An oscilloscope camera adaptable to any type of 5 in tube and incorporating a 1:1 high-speed lens, with a viewing aperture for accurate viewing and positioning, has been developed by **Hamilton Watch Co., Hathaway Instrument Div., Sept. S/A, 5800 E. Jewell Ave., Denver 22, Col.** It renders continuous records on photo-sensitive paper or film; a filter in the viewing aperture makes continuous viewing possible while the camera is operating.

Type C6 camera has two interchangeable gears, one for a speed of ¼ to 17 in per second; the other for speeds of 5 to 275 in per second.

Write in No. 338 on Reader Service Card

more on page 244

Reeves INSTRUMENT CORPORATION *is part of the picture on front page projects of today.*

A HIGHLIGHT ON CREATIVE SYSTEMS ENGINEERING AT Reeves

PRECISION...ON A SPACE-HIGH PEDESTAL

Reeves has pioneered in the development of extremely high precision two- and three-axis antenna pedestals for fire control, guidance and tracking systems. Reeves-engineered pedestals and related electronic assemblies, including servo systems and computers, are production-ready in types for both land-based and shipboard applications. The pedestals provide continuous rotation in azimuth, with angular travel in the remaining two axes designed to meet particular requirements. Accuracies in the order of 0.1 milliradians can be achieved, with rates of 10 degrees per second, or higher.

REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America

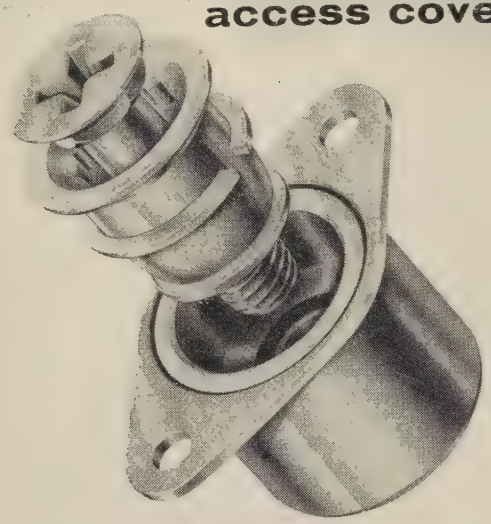
Roosevelt Field, Garden City, New York

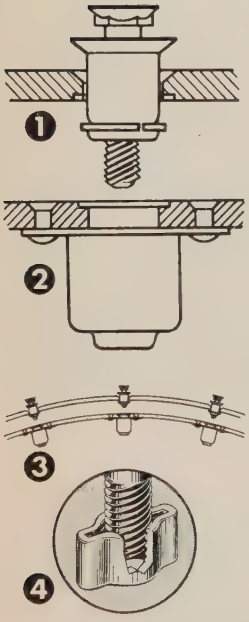
Qualified engineers who are seeking rewarding opportunities for their talents in this and related fields are invited to get in touch with us.

Front page projects of tomorrow are part of the picture at Reeves INSTRUMENT CORPORATION

Write in No. 183 on Reader Service Card at start of Product Preview Section

MONADLOC high shear fastener for quick release of stressed doors and access covers





Consists of a bushing assembly, retained in the panel (see figure 1), and a receptacle assembly riveted to the structure (see figure 2). Bushing assembly is retractable to almost flush with underside of door permitting removal of curved panels as easily as flat panels (see figure 3). With screw held securely in bushing assembly, Monadloc eliminates expense and time-loss of wrong length screws and lost parts common to screw-and-nut fastening. With quadruple lead thread, Monadloc opens and closes in ¼ the time of a conventional screw. Unique bellows type self-locking nut (see figure 4) has withstood up to 2500 locking and unlocking cycles without losing locking torque efficiency. Assures tensile, torque out, vibration and other high performance characteristics of the fastener.

PERFORMANCE CERTIFIED TO FOLLOWING MINIMUM REQUIREMENTS

Ultimate tensile load; 2500 lbs. minimum • Ultimate shear load; 5500 lbs. minimum • Sheet separation; less than .007" at rated load • Locking torque; 40 lb./in., maximum • Unlocking torque; 40 lb./in., maximum • Sheet pull up; 3/16" minimum • Shear fatigue; 10,000 cycles minimum at 1800 CPM 0-1850 lb. load • Vibration fatigue; 20,000 cycles minimum at 1900 RPM ± 725 lb. load • Corrosion resistance; meets QQ-M-251 200 hour salt spray • Sonic vibration fatigue; total 6 hours at 156-165 DB sound levels • Torque out; 100 lb.-inch • Bushing push out; 1000 lbs., minimum • Receptacle push out; 200 lbs., minimum • Endurance; retains self-locking characteristics through 2500 cycles.

Write for circular

MONADNOCK MILLS
SAN LEANDRO, CALIFORNIA
SUBSIDIARY OF
UNITED-CARR FASTENER CORP., BOSTON, MASS.

OFFICES: ATLANTA, BOSTON, CHICAGO, CLEVELAND, DALLAS, DETROIT, LOS ANGELES, NEW YORK, PHILADELPHIA, SYRACUSE

Write in No. 169 on Reader Service Card

ACCELEROMETER is gas-damped

This linear accelerometer operates with ac excitation power and provides an ac output voltage proportional to the applied acceleration. The seismic mass is supported by two flexure elements that allow a low spring constant along the sensitive axis, but provide exceptionally rigid constraint on the non-sensitive axes, says **Genisco, Inc., Dept. S/A, 2233 Federal Ave., Los Angeles 64, Calif.** The unit is gas damped to provide an essentially constant damping ratio over a wide temperature range.

The pickoff is electrically similar to a rotary differential transformer.

Write in No. 339 on Reader Service Card

SUBMINIATURE CLUTCH has 20 in.-oz torque

This subminiature precision magnetic duplex clutch is said to have high total torque output, 20 in. oz at 3.5 watts, and zero backlash. Weight is 2.4 oz, response time 8 milliseconds. It can be supplied for voltage applications of 6 to 115 dc, says **Orbit Instrument Corp., Dept. S/A, 131 Eileen Way, Syosset, L. I., N. Y.** It is available in reverse or direct acting types and in any combination of brake and or clutch actions.

The same basic design is available with a ¼ in. diameter input shaft substituted for the input flange. Shafts of varying lengths are supplied to order.

Write in No. 340 on Reader Service Card

TIMER in explosion-proof case

This "Duo-Set" miniature repeat cycle dial timers in explosion-proof case meets NEMA specifications of Class I, Group D, Div. 1 and Class I, Groups E, F and G. It is for use in hazardous atmospheres, the Series 306A timer controls two independently adjustable load circuits, eliminating the need for two timers, says **Automatic Timing & Controls, Inc., Dept. S/A, King of Prussia, Pa.** Load ratings are 10 amp at 115 Vac, 5 amp at 230 V ac or ¼ amp at 115 V dc.

The unit features simple know-setting of time intervals from ½ sec to 4 hours in a wide selection of dial ranges.

Write in No. 341 on Reader Service Card

SMALL INDUCTORS with high Q values

Designated as series 785, these inductors are fully encapsulated and hermetically sealed to meet military spec. A typical 1 mh inductor operating at 40 Kc has a maximum Q of 240, says **Arnold Magnetics Corp., Dept. S/A, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.**

Units are supplied with inductance values from 1 millihenry to 7 henries, in a useful frequency range of from 1 Kc to 100 Kc. Case meosurts 1 1/16 in diam. by ¾ in. high and weighs only 2.3 oz.

Write in No. 342 on Reader Service Card

SOLENOID VALVE is highly versatile

Weighing .21 lb, this 400 cycle, non-rectified ac solenoid valve is adaptable to a wide variety of sizes and configurations. It is capable of handling any fluid such as solvents, hydraulic fluids, fuels or hot gases, according to **Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa.**

The unit is said to be able to perform the same jobs expected of larger, heavier units of the type.

Write in No. 343 on Reader Service Card

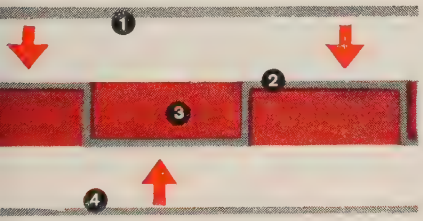
more on page 246

Johns-Manville Announces... MIN-KLAD INTERLOK

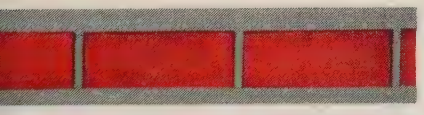
. . . a new structural system interlocking Min-K insulation and high-temperature reinforced plastic

Missile experience shows that in certain heat control situations no one material will perform as well as two (or more)—*in insulation with protective high-temperature facings.*

Problem is how to effectively combine these materials into a structurally strong unit? The answer is Min-Klad Interlok



1) Outer facing, 2) Interlocking web, 3) Core, any one of several Min-K formulations, and 4) Inner facing.



All the above components combine to provide a custom-made structural strong insulating system.

—a new structural system that interlocks Min-K insulation and reinforced plastic, metal or other high-temperature facings.

The result: one product that gives the missile designer every advantage of high-temperature plastic or metal foil—strength, toughness, rigidity! Erosion resistance! High heat capacity!

. . . plus the outstanding advantages of Min-K insulation—an insulating core that has the lowest thermal conductivity available for service temperatures up to 2000°F steady-state, and higher for transients. Min-K's thermal conductivity is actually lower than the molecular conductivity of still air.

Wide range of facings

For the hot face, the missile designer can specify Min-Klad Interlok in a wide variety of heat-resistant and/or ablating materials—asbestos-phenolic (ARP-40), and similar reinforced plastics, as well as stainless steel and other heat-resistant metal foils and meshes. For some requirements, the cool face can be made of a different material—for example, one that offers characteristics required for bonding or fastening to other surfaces and parts.

Like all J-M Aviation insulations, Min-Klad Interlok is factory-fabricated to your specifications into external skin panels, heat shields, cylindrical liners or component housings of any shape or size. Write today for technical specifications. Address Johns-Manville, Box 14, New York 16, New York. In Canada, Port Credit, Ontario.

JOHNS-MANVILLE JOHNS MANVILLE JM PRODUCTS

Write in No. 184 on Reader Service Card at start of Product Preview Section

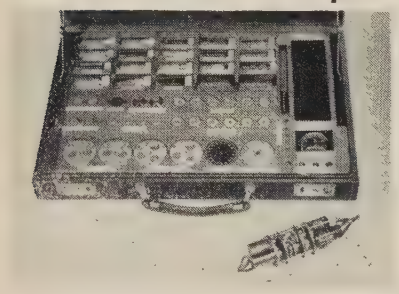
CONNECTORS with thermocouple circuits

These thermocouple connectors with ceramic inserts are designed to withstand temperatures up to 1000 deg F. and can be used in power as well as thermocouple circuits. Models are in five, nine, and eleven contact configurations within a shell of 1¼ in outside diameter, says **Harco Laboratories, Inc., Dept. S/A, 77 Olive St., New Haven, Conn.**

The pins and sockets are in chromel, alumel, copper, constantan and iron with welded, soldered or brazed connections for up to number 14 wire.

Write in No. 344 on Reader Service Card

SERVO KIT from stock parts



This Kit No. 1 contains all mechanical parts and tools necessary to construct 1 7/8 in diameter mechanisms up to the complexity of the computer component shown. The completed mechanisms can be sealed into standard 2 in diameter enclosures for airborne applications and prototype evaluation, according to **Servo Development Corp., Dept. S/A, 567 Main St., Westbury, N. Y.** Rotating units such as motors, potentiometers, and synchros are not included.

This pre-engineered system, it is said, assures rapid, economical and interference-free construction for developmental, laboratory, prototype or production applications requiring small precision servos.

Write in No. 345 on Reader Service Card

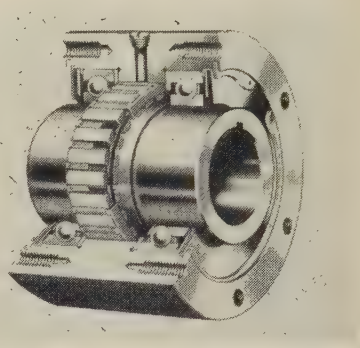
AC MOTOR operates to 65,000 ft

This s-phase, 400 cycle, 200v ac motor weighs 6.2 lbs. It is 7.625x 5.190x3.875 in, says **Hoover Electric Co., Dept. S/A, Hangar Two, Port Columbus Airport, Columbus, Ohio.** It has super precision ground aircraft ball bearings.

Features include an integral cooling fan, close tolerance reduction gearing, high temperature windings and insulation, and will operate to 65,000 feet.

Write in No. 346 on Reader Service Card

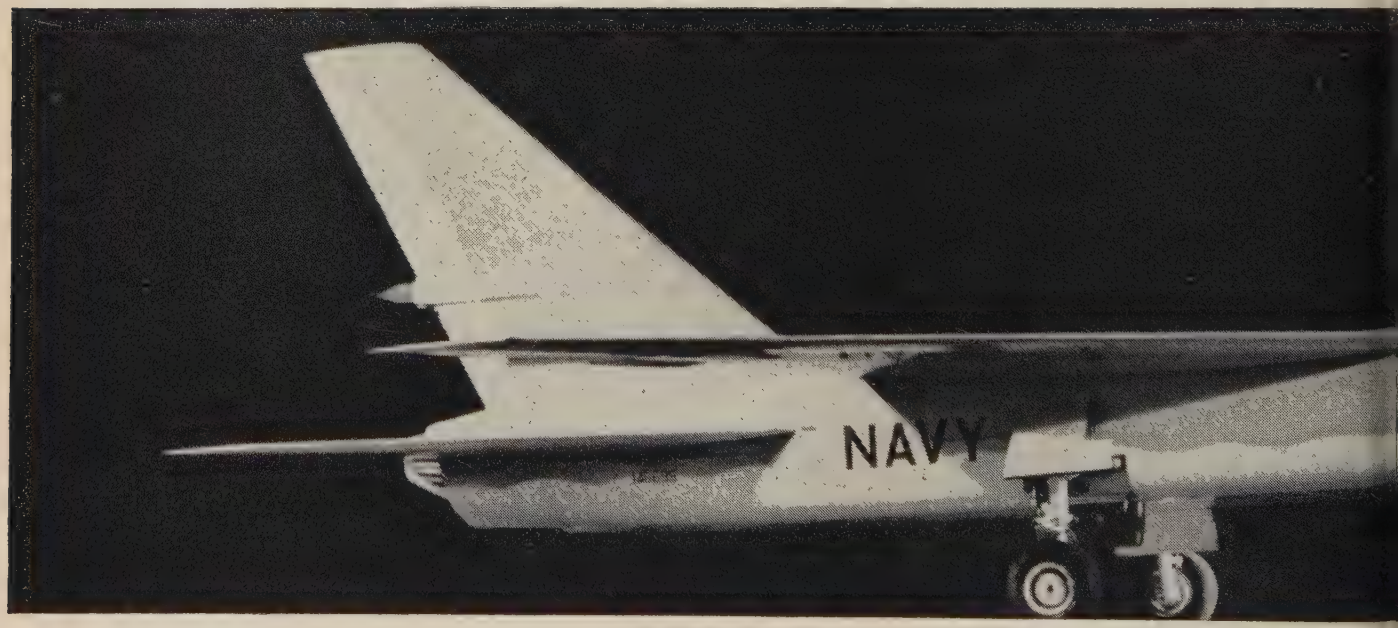
CLUTCHES have improved sprags



These over-running HPO and HPI indexing clutches are said to have an improved sprag design and retainers that assure a coordinated movement of all sprags. Each sprag also has a free-action feature, says **Formsprag Co., Dept. S/A, 23601 Hoover Rd., Warren, Mich.** On 15 degree indexing, the HPI clutch with a torque capacity of 475 lb ft can be operated at 1200 indexes per minute without slip or backlash.

The HPO clutch design can be modified for special applications requiring high over-running speeds up to 20,000 rpm.

Write in No. 347 on Reader Service Card



VIGILANTE:
a "decathlon winner" airplane

It's easy to make an airplane to excel in one thing. It's hard to make one that excels in many. But there is no room on a carrier deck for an aircraft that has muscle for only one kind of job.

The Navy now has an "all-round champ"—a manned weapons system called the A3J Vigilante. Manufactured by the Columbus Division of North American Aviation, production models of this advanced aircraft are now in Navy flight evaluation. This slim, needle-nosed weapon of some 70 feet in length has the power to whip its 25 tons off a pitching carrier deck, climb swiftly into the stratosphere and fly at Mach 2 speeds... yet is controllable enough to land like a gull either on the carrier or on small fields ashore.

SWITCH
for acceleration

This model 1347-1 acceleration switch closes two normally open contacts when a carrier vehicle has accelerated to a specified distance from its starting point and closes a single switch when the unit has accelerated to specified arming distance, says **Raymond Engineering Laboratory, Inc., Dept. S/A, Smith St., Middletown, Conn.** It is hermetically sealed and weighs less than 90 grams.

Environmental capabilities include reliable operation during and after exposure to temperature range of –65° F to +165° F.

Write in No. 348 on Reader Service Card

TINY TERMINAL BLOCKS
snap together to stay

This semi-elastic zytel series G Alpha Blocks, in ten colors for circuit coding, snap to form rigid rows which cannot separate after being fastened down. Insulating barriers are integral in each block, which measure ⅜ in wide, $^{13}/_{32}$ in high to top of barrier, ¼ in. high to top of block, ¾ in. long, according to **Alpha Electric Products Co., Dept. S/A No. Halsted St., Chicago 13, Ill.** Rating is 20A at 110v.

Full insulation protection is provided between blocks and fastening screws and panel: and between block pairs. Electrical connection between pairs is an integral part of the block.

Write in No. 349 on Reader Service Card

CAMERA
for missile trials

Designated as camera, Target Aircraft Type W.R.E. No. 1 Mk. 1, F.A.C. Type F-136-A, this camera, which is mounted on a target for guided weapon trials, is for use on the Jindivik and other target aircraft to assess guided weapon performance. In the Jindivik installation, cameras are mounted in pairs. Full coverage may be obtained by virtue of the ultra wide angle lenses employed, which have a field of view greater than 180 degrees, says **Fairey Aviation Co., Dept. S/A, 24 Bruton St., London, W.I.**

These installations are said to offer a weight-saving advantage by halving the number of cameras required, and also enable the cameras to be designed with a view to reducing pod diameter to a minimum. The pods being made to accommodate them are of 5½ in. outside diameter. The running speed is about 100 fps and the exposure time is one millisecond. The weight of the camera unit is 14½ lb and the maximum diameter 5.3 in.

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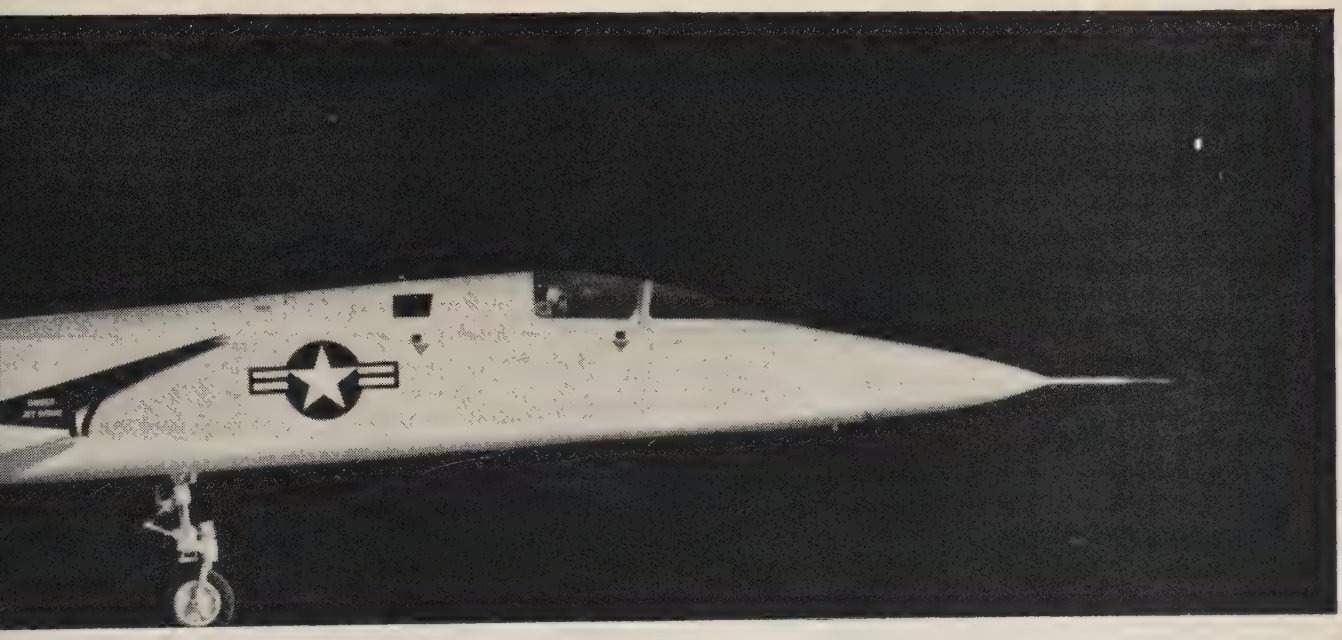
EXTRUDED TEFLON
in intricate shapes

These dimensionally accurate Teflon extrusions for electrical, electronic and mechanical applications are available in continuous shapes or profiles made from intricate, segmented dies and are said to eliminate machining of rod or tube stock, and the need for molds. They have a continuous service temperature of 250° C and are impervious to almost every kind of corrosive attack, says **Pennsylvania Fluorocarbon Co., Dept. S/A, Philadelphia, Pa.**

Applications include shaped insulators, spacers, supporting channels or ductwork for electrical circuits, and terminal receptacles or plugs.

Write in No. 351 on Reader Service Card

more on next page



e A3J is formidably equipped with integrated elec- c systems and auto-flight controls, so that regardless eather or target accessibility—day or night—it can sely deliver nuclear or conventional warheads from ltitude, from any attitude, and at distances ranging 1000 miles from the carrier.

plane that can double, too, for reconnaissance and intelligence missions—yet has speed and maneuverability to perform single-plane attack missions without escort.

A dream? The men who fly it say she is. She is perhaps as close as you can come to being all things to all pilots.

Her versatile capability will strengthen our Navy for either "brush-fire" warfare or all-out nuclear conflict for many years to come. The name again: A3J Vigilante.

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Columbus, Ohio

INSTANT ROCKET EXHAUST ANALYSIS

10,000 complete analyses per second of 10,000°C. flames now possible with new

BENDIX* MASS SPECTROMETER

We offer the basic tool for analysis of fast reactions, such as plasma jets and rocket exhaust. Model 14 of the Bendix Time-of-Flight Mass Spectrometer combines a high-speed, line-of-sight sample inlet with fast pump-out of the analyzer region so necessary for this difficult analysis. Both plus and minus flame ions can be analyzed as well as neutral radicals and molecules.

Our engineering department is ready to work with you on solving your specific sample inlet problems, as well as other research and development projects in the missile and rocket field.

For complete details on this and other applications, plus a copy of The Dow Chemical Company report "Time-of-Flight Mass Spectrometry and Gas-Liquid Partition Chromatography," contact the Cincinnati Division, Dept. X2, 3130 Wasson Rd., Cincinnati 8, Ohio.

*REG. U.S. PAT. OFF.

Cincinnati Division
CINCINNATI, OHIO

Bendix
AVIATION CORPORATION

Export Sales: Bendix International Division, 205 East 42nd Street, New York 17, New York
Canada: Computing Devices of Canada, Ltd., Box 508, Ottawa 4, Ontario.

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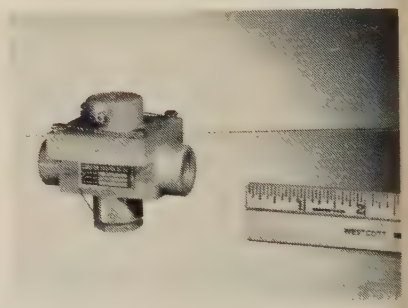
RECEIVING SYSTEM is extremely sensitive

Model 90208-2, Microlock Receiving System receives low-level beacon signals from a missile- or satellite-borne transmitter to permit accurate measurements of velocity and position and to allow recording of telemetered information, says **Resdel Engineering Corp., Dept. S/A, 330 So. Fair Oaks Ave, Pasadena, Calif.**

The sensitivity of the system to low-level signals (—150 dbm) allows the use of a light-weight, low-power transmitter. Angular position can be determined to an accuracy of 1 mil. The unit is available in a standard relay rack with power supplies and monitoring equipment.

Write in No. 352 on Reader Service Card

MINIATURE REGULATOR for high pressure



This single-stage, high pressure, miniature regulator for life support systems in space, model No. 1400, is regulated by its single stage mechanism. All components are metallic, says **Carleton Aviation Co., Inc., Dept. S/A, E. Aurora, N.Y.** It is applicable to helium, nitrogen and other gases in addition to oxygen systems.

Design includes flow pressure, 2.4 lb per min; outlet pressure, 100 ±10 psi; proof pressure, 16,700 psi; burst pressure, up to 22,000 psi.

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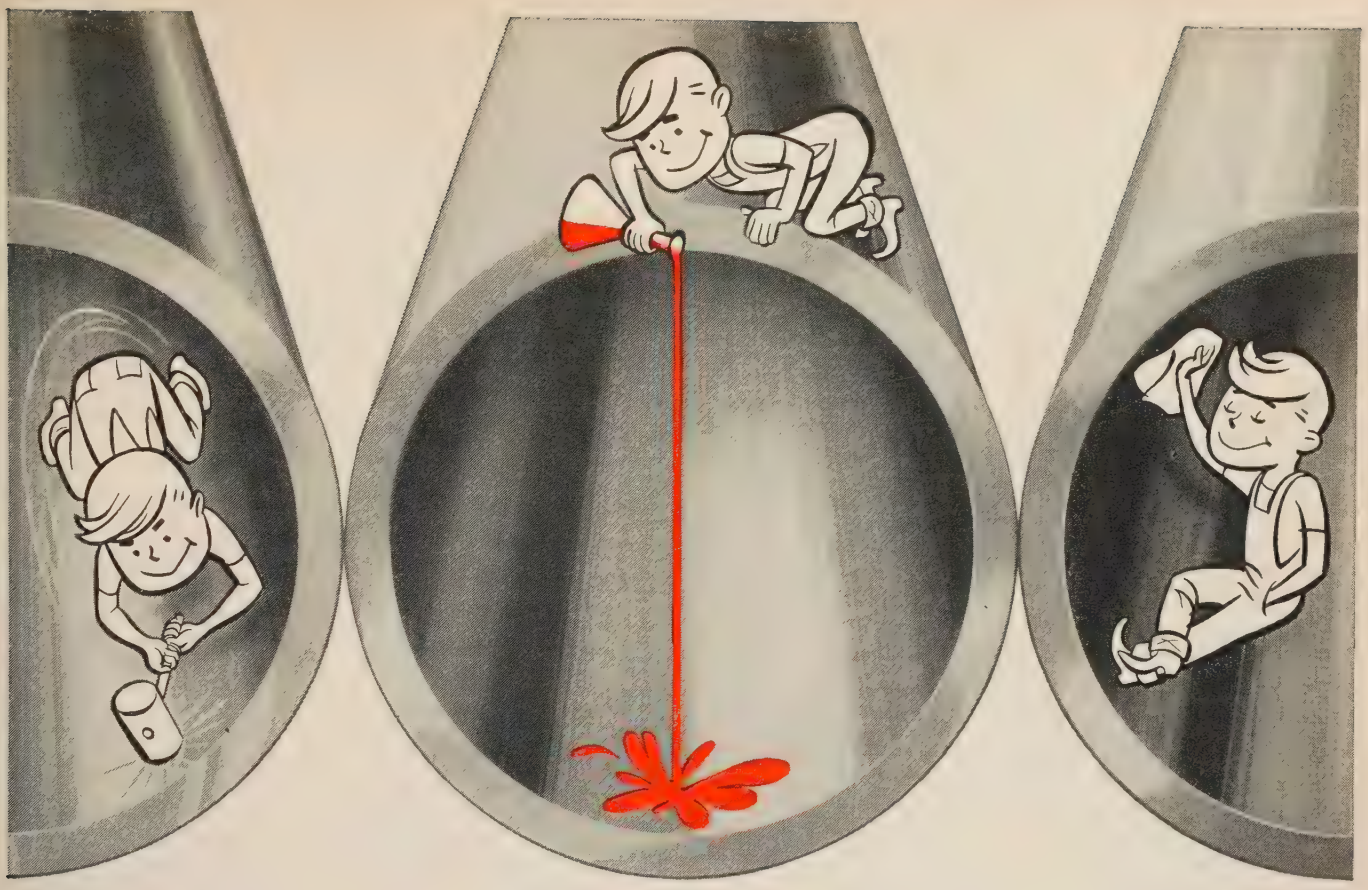
POWER METER is self-balancing

Model 440, microwave Power Meter is fully transistorized and self-balancing to provide accurate, automatic direct-reading measurements of cw or pulsed power, says **Narda Microwave Corp., Dept S/A, Mineola, L.I., N.Y.**

The meter provides the widest power measuring range available, with 0.001 to 0.01 mw and 0.003 to 0.03 mw scales, in addition to the 5 standard scales up to 10 mw. The meter is powered by a nickel-cadmium battery which operates 16 hrs before a recharge by 115 v 60 cps power is required. Battery can be recharged during operation.

Write in No. 354 on Reader Service Card

more on page 250



The smoother surface of

CONTOUR-WELDED* STAINLESS TUBING

gives it greater resistance to corrosion

Recent tests prove: (1) *Contour-welded* tubing is smoother than any other tubing, and (2) this extra smoothness provides greater resistance to corrosion.

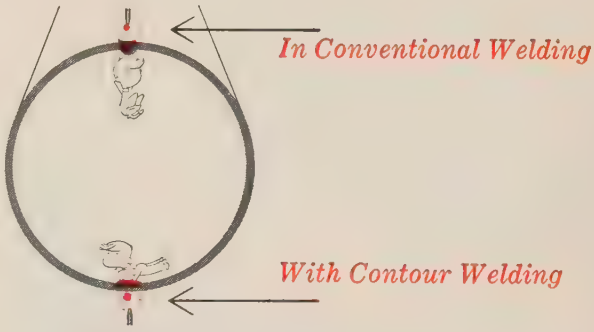
Here's how TRENTWELD® tubing, made by the exclusive *Contour-Weld* process, compares with other full-finished tubing:

- It's smoother than seamless because it's formed from uniformly rolled strip steel, whereas seamless is extruded from a billet.
- It's smoother than other welded tubing because the *Contour-Weld* process, patented by Trent, virtually eliminates the weld bead.

Other tests prove this smoother surface provides *increased resistance to corrosion* — because there are fewer focal points for corrosive attack. Not only that, the smoother surface ensures *longer fatigue life* and *less product incrustation.*

But get full details. Our free 48-page *"Trentweld* Manual" gives complete data on *Contour-Welded* tubing in sizes from ⅛" to 40" O.D., in stainless and high alloy steels, titanium, zirconium, zircalloy and Hastelloy.† Write: Trent Tube Company, Box 2518, Pittsburgh, Pa.

†Trademark Haynes Stellite Co.



In **CONVENTIONAL WELDING** of tubes, gravity pulls the molten metal down to form a bead that is difficult to remove by cold working. And cold working may lead to undercuts, focal points for fatigue cracks and corrosive attacks. Cleaning becomes difficult.

***With CONTOUR-WELDING** the tube is welded at the bottom. Gravity still pulls the molten metal down inside the tube, but now the weld area corresponds to the contour of the tube. There's virtually no weld bulge on the inside surface. And even on the O.D., the weld seam more closely conforms to the contour of the tubing.

CONTOUR TRENTWELD®

stainless and high alloy pipe and tubing

TRENT TUBE COMPANY

Subsidiary of Crucible Steel Company of America • GENERAL OFFICES: East Troy, Wisc. • MILLS: East Troy, Wisc.; Fullerton, Calif.

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(Orders also accepted.)

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Specify width.

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GRANT PHOTO PRODUCTS, INC.

19000 Detroit Ave., Dept. D-13, Cleveland 7, Ohio

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STATIC INVERTER weighs eight pounds

This static inverter to convert dc to ac supplies 100 Va of 3 phase ac power at 115 v/phase on missiles operating outside the earth's atmosphere. It weighs 8 lb and overall dimensions are 7¾x4½x4½. Mounting dimensions are compatible with MS 25092 and inverter will meet MIL-I-7032D says **Electrosolids Corp., Dept. S/A, 13745 Saticoy St., Panorama City, Calif.** The output frequency is 400 cycles, 2 cycles, with a maximum distortion of 5 per cent at any load.

Efficiency of the inverter is better than 70 per cent with a phase balance of 120 deg ±5 deg. It is designated W1298-2 and was designed to be cooled by radiation and is capable of operating in excess of 100,000 ft without special cooling considerations.

Write in No. 355 on Reader Service Card

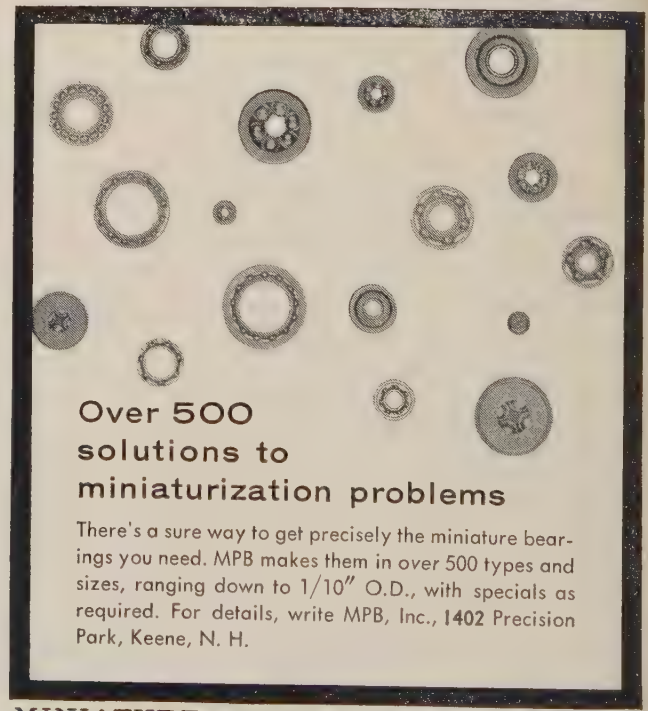
GLOBE VALVE has balanced pressure

A 2½ in IPS pressure balanced globe valve, designed to balance the pressure on both sides of the seat, removes all operating forces from the stem except those of seal friction, according to an announcement by **Dumont Aviation Associates, Dept. S/A 1401 Freeman, Long Beach, Calif.** Maximum torque required to seat or unseat the valve was said to be 150 in lb after which the necessary operational torque is less than 10 in lbs.

Body is an alloy steel casting in conformance to ASTM-A-148-55 Grade CI-90 fully annealed and was designed specifically for air, similar gases or light oil at an operating pressure of 4000 psi and hydro testing at 6000 psi within the temperature range of —60 deg to +250 deg F.

Write in No. 356 on Reader Service Card

more on page 252



Over 500 solutions to miniaturization problems

There's a sure way to get precisely the miniature bearings you need. MPB makes them in over 500 types and sizes, ranging down to 1/10" O.D., with specials as required. For details, write MPB, Inc., 1402 Precision Park, Keene, N. H.

MINIATURE PRECISION BEARINGS INC.

MPB

Helps you perform miracles in miniaturization

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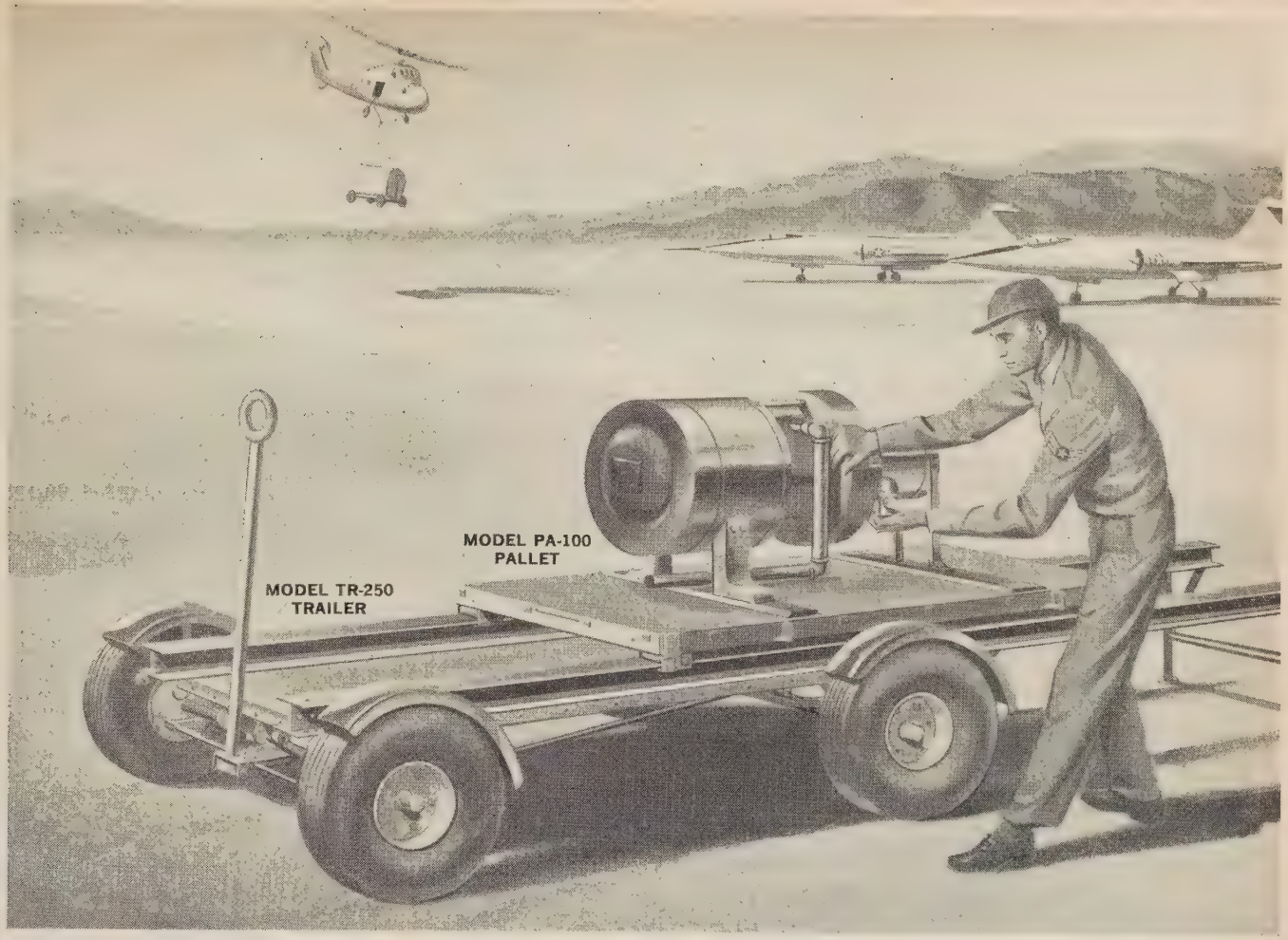

today's most versatile, light weight

TRAILER-PALLET HANDLING SYSTEM

designed for greater mobility, rugged long life, complete supply capability

The combination of American Electronics Model TR-250 Universal Roll-Transfer Trailer with the Model PA-100 Basic Pallet provides maximum flexibility in logistical and ground support service. Used together or separately, these versatile units and their accessories are designed for a wide variety of ground support applications. *Please write for the new brochure giving complete details on AEI's Universal Trailer-Pallet System.*

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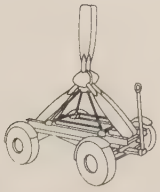
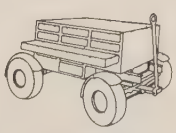
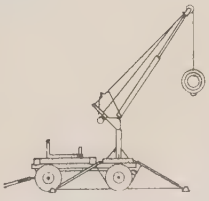
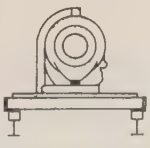
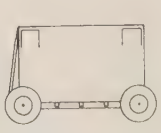
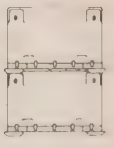

COMPONENT HANDLING


WORK BENCH


JIB CRANE


ENGINE REPAIRS


CONTAINER


SUPPLY TRANSFER

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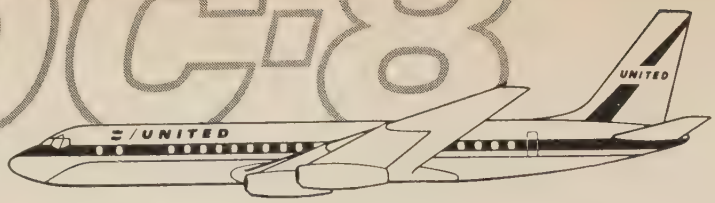
DC-8

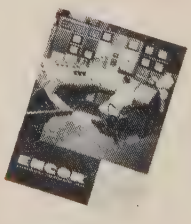


JETS GET THEIR FLIGHT PLAN DATA PROCESSED BY COMPUTOR HOUSED IN

EMCOR®* CABINETS

An EMCOR cabinet houses an electronic computer designed to furnish flight plan data for DC-8 Jet Mainliners, United Air Lines, Chicago, Illinois. The computer stores in its memory the operating and performance characteristics of the DC-8 aircraft, including such things as fuel flow, air speed, rate of climb, routes, altitude restrictions, compass headings, distance between check points, etc.

EMCOR design "know-how" in producing standard cabinets featuring the most modern concept in metal cabinetry is keeping pace with the new age in air travel. The flexibility, versatility and structural capabilities of over 600 basic frames in the EMCOR MODULAR ENCLOSURE SYSTEM bring advanced engineering and "imagineering" to meet electronic and instrument packaging requirements.



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Originators of the Modular Enclosure System

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DAMPED SERVOMOTORS in two types

The 115-V, 400-cycle inertia and velocity damped servomotros in this line are available in Sizes 11, 15 and 18, and which are rated for stall torques of 0.63, 1.5 and 2.35 oz-in., respectively, says **Beckman Instruments, Inc., Dept. S/A, 2500 Fullerton Rd., Fullerton, Calif.** Passivated stainless steel housings, corrosion-resistant, high temperature laminations, and encapsulated windings are featured in all units.

The Size 11 model has a 1.3 gm cm^2 rotor inertia with a maximum additional damping factor of 155 dyne cm sec/rad in the inertia damp type and an adjustable damping range of ten to 100 dyne cm sec/rad in the velocity damp type. The Size 15 and 18 types have increases in rotor inertia and damping ratings corresponding to the increase in size. For example, rotor inertia for the Size 15 is 2.0 gm cm^2, and for the Size 18, it is 4.5 gm cm^2.

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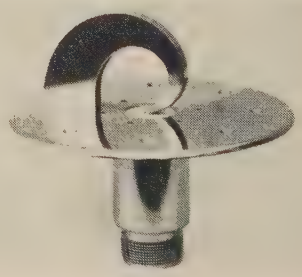
ANTENNA has scimitar design



Three or more conventional electronic countermeasure antennas can be replaced by the scimitar antenna, the result of a design that also permits production of minimum drag antennas capable of operating at frequences below 200 mc, says **Tamar Electronics, Inc., Dept. S/A, 2339 Cotner Ave., Los Angeles 64, Calif.** The configuration of this new type of antenna derives from use of the shape coefficient for establishing the outer curve and another value for the inner curve in the spiral equation.

The antenna performs like a stub antenna in the horizontal plane and a dipole in the vertical plane. It possesses omni-directional characteristics, and it may be used in clusters to make possible numerous radiation patterns and polarization ratios. Frequency ranges include: 350 to 1000 mc; 950 to 2350 mc; and 2350 to 5000 mc. The antennas are rated for 5 0 W of CW power, and VSWR is 1.25:1. Efficiency is said to be 95 per cent.

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more on page 254

Will tomorrow be a challenge . . . or a bore?

If you feel that your present job is not fully tapping your potential, here are 4 new career opportunities for Electronics Engineers that have every bit of the challenge you may be looking for . . .

1 *Site Systems Reliability Engineer:* This position calls for a seasoned engineer capable of integrating and directing on-site reliability assurance activities necessary to secure customer acceptance of the detection system. Unusual combination of technical ability, relations and communications (written and spoken) is required. Desirable experience includes approximately ten years in design and field installation of transmitters on electronic systems with ability in both electronic and mechanical fields. Ability to motivate technicians for optimum performance is necessary. Salary structure is equal to the challenge.

2 *Radar Equipment Systems Specialist:* This position calls for a creative engineer capable of conceiving and directing the design of long-range radar systems. Desirable experience includes around ten years in at least one of the following: radar systems design, antenna systems, R.F. components, radar receiver systems or radar data processing systems. Salary structure is equal to the challenge.

3 *Advanced Systems Engineer:* This position calls for a creative engineer capable of defining future defense and space detection problems as well as the ability to conceive and establish the feasibility of optimum systems solutions to these problems—making use of the most advanced techniques and understanding. He must recognize the need for and coordinate the development of new techniques and the exploration of new phenomena in the area of detection systems. Background desired: Bachelor degree plus a combination of advanced training and several years experience in both the theoretical and practical aspects of detection systems engineering. A desire to work in the conceptual phase of system design with the analytical ability required to evaluate and demonstrate the effectiveness of proposed systems.

4 *Advanced Radar Systems Analysis and Development Engineer:* Engineers are needed who are able to visualize and define future defense and space problems—conceive advanced radar systems to solve them. An advanced degree and/or strong background in system analysis and design is essential. Assignments open include: analyze and define requirements for advance detection systems and determine broader parameters for such systems, establish their feasibility; analyze long range missile detection systems and specify optimum configuration on the basis of utility, performance, cost and delivery. 228-9

All of these openings are on General Electric missile and satellite detection projects and will be filled with engineers having the capability and desire to make creative contributions.

Write in confidence to T. M. George, Supervisor—Personnel Administration

Missile Detection Systems Section
HEAVY MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

SYRACUSE, NEW YORK

Check Employment Inquiry Form on Page 161

ELECTRICAL · AIRCRAFT · ELECTRONIC · AUTOMOTIVE
COMMUNICATIONS · ANY INTRICATE WORK

Here are real timesaving tools for electrical and electronic assembly and maintenance, or any other limited space work.

Thin driver blade tip is the same width as the shank diameter, to follow screw below surface or work among intricate assemblies. Blades are made from extra-tough alloy steel for long life. Tips are precision-machined to seat properly in screw slots to prevent slippage and damage.

Crimped shanks anchor firmly to prevent turning in handles. Two blade widths — 1/8 in. and 3/16 in. Blade lengths of from 2 in. to 10 in. Available individually or in sets of five.

Insulated handles are shockproof and practically unbreakable. "Octo-Grip" handle shape prevents tool from rolling and provides for a powerful turning grip without hurting the hand.

Put new speed in those limited space jobs with these new SNAP-ON thin-blade screwdrivers. They'll pay for themselves in short order. Write us or call your nearest SNAP-ON branch.

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SNAP-ON TOOLS
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CHECK VALVE for extreme temperatures

This check valve is designed for service where temperatures, gases or fluids preclude use of an elastomeric bory seal and for systems where extreme operating temperatures, —300 to 500 deg F. are encountered says **James Pond & Clark, Inc., Dept. S/A, Pasadena, Calif.** It is designed for 0-600 psi.

When open, the full flow passages and streamlined internal configuration provide pressure drop comparable to aircraft swing check valves. When closing, a floating O ring automatically establishes line contact with conical metal surfaces of poppet and seat to cushion closing. When closed, conical sealing faces exert light tension of ID of O ring to insure smooth sealing surface.

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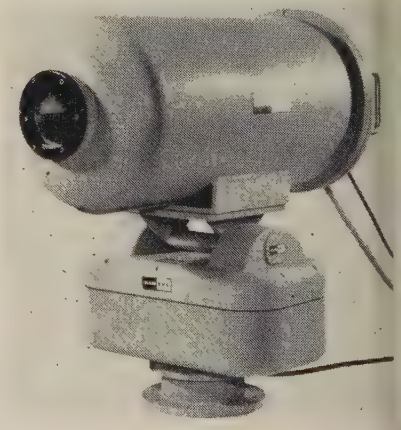
TV MOUNT for area surveillance



This heavy duty television camera circles from side to side in continuous back and forth action, panning the TV camera over an adjustable sector. Built-in speed controls allow the scanning cycle to be varied over a wide range, says **Cohu Electronics, Inc, Kin-Tel Div., Dept S/A, Box 623, San Diego 12, Calif.**

Model ARC11B has been designed specifically to support heavy acoustical or weather proof housing such as are used near outdoor camera stands. A single control panel 3000 ft away from the camera provides complete command over the scanning action.

Write in No. 362 on Reader Service Card

more on page 256

He kept the crib from rocking

For accurate firing, Titan and its subterranean steelwork crib must be kept in absolute alignment with the earth's center despite natural movements of the crust or nuclear shock. This AMF production engineer's problem was to build the shock absorbers AMF designed for the job. These are massive, pneumatic cylinders constructed of precision-fabricated, precision-fitted steel parts.

Now, it's no particular trick to fit ultra-fine-tolerance parts together if they're of manageable size. But how, as in this case, could he slide a 600-pound, 6-foot-long steel tube, 1¼ feet in diameter, into another tube when the clearance between the two is *less than 3/1,000 of an inch?* How could he maintain alignment to prevent Brinelling or scouring as one slid a full ten feet into the other?

Here's what he did: He put down heavy steel tracks for a series of wheeled carts. He mounted the tubes on carts, adjusted position... and, slid them together.

Single Command Concept

This ingeniously simple but unique horizontal assembly concept is *one more* example of AMF production know-how in action.

AMF people are organized in a single operational unit offering a wide range of engineering and production capabilities. Its purpose: to accept assignments at any stage from concept through development, production, and service training... and to complete them faster...in

- *Ground Support Equipment*
- *Weapon Systems*
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- *Range Instrumentation*
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AMF

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AMERICAN MACHINE & FOUNDRY COMPANY

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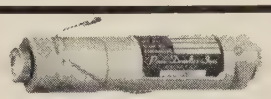
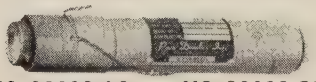
MS 28893-A4 MS 28893-C4
MS 28893-B4 MS 28893-D4



MS 28893-A6 MS 28893-C6
MS 28893-B6 MS 28893-D6



MS 28893-A8 MS 28893-C8
MS 28893-B8 MS 28893-D8

*MIL-V-8813 (ASG) (Supersedes MIL-V-5523B)

- *Higher operating temperatures (275°F)*
- *Lower spread — full flow to reseat*

Especially applicable to auxiliary power system pressure control.

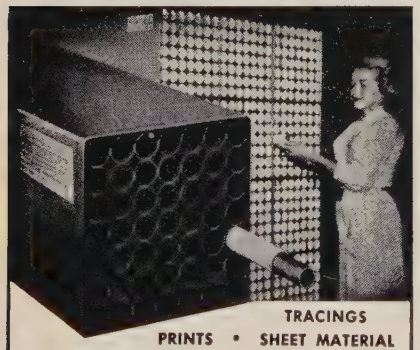
Valve Features: 1. No Dynamic O-Rings, no hysteresis; 2. Dash pot, no noise or chatter; 3. No outlet jet effect; 4. Flow compensated operation; 5. Light wt., low stress springs.

PneuDraulics, Inc.

8961 Central - Montclair, Calif. - NA 9-0677
Request Technical Information on your letterhead

Write in No. 207 on Reader Service Card

MULTIROLL FILES



TRACINGS
PRINTS • SHEET MATERIAL

QUICK, FILING AND WITHDRAWAL

Depth	11¼"	22¼"	30½"	36½"	42¼"
49 Tube 1¾" I.D.	49AB $7.50	49CD $9.50	4930 $12.80	4936 $13.80	4942 $14.80
MODEL 25 Tube 2¼" I.D.	25AB $7.00	25CD $9.00	2530 $11.80	2536 $12.80	2542 $13.80

Shipping Weight

Model 49	8 lbs.	12 lbs.	15 lbs.	18 lbs.	20 lbs.
Model 25	6 lbs.	10 lbs.	13 lbs.	15 lbs.	17 lbs.

ENAMELED DARK GREEN OR MED. GRAY - State Color

JR 36
Designed to Mount Under Board—Mounting Brackets Furnished. Gray Only.

9.50 SET of TWO

Sold in Sets Only—2 JR36 Per Set

8 lbs. Ship. Wt.

• SOLD DIRECT ONLY Write to Dept. BP
F.O.B. St. Clair Shores, Mich. • PRescott 3-2515

ROLL & FILE SYSTEMS, INC. P. O. BOX 3863 B DETROIT 5, MICH

Write in No. 208 on Reader Service Card

CONDUCTIVE CABLE has high strength

This conductive cable has a special swaged terminal which grips the cable end to full strength, yet permits the electrical conductor to pass through without compression damage. Of ⅞ in diameter, breaking strength as high as 65,000 lb has been successfully demonstrated, says **Bergen Wire Rope Co., Dept. S/A, Lodi, N. J.**

Other characteristics are its non-rotating feature and hermetically sealed design.

Write in No. 440 on Reader Service Card

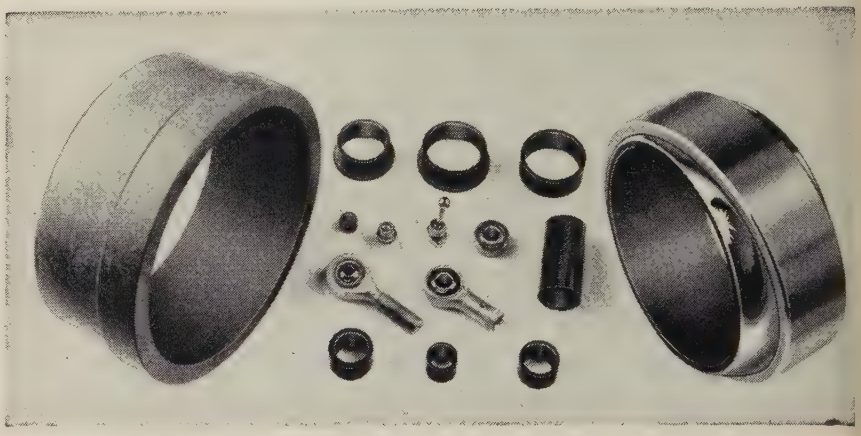
ELECTRIC MOTOR is self-cooled

This totally enclosed, self cooled, ¼ hp 3300 rpm electric motor is designed to conform to specifications CC-M-636, says **Western Gear Corp., Electro Products Div., Dept. S/A, 132 W. Colorado Blvd., Pasadena, Calif.** The motor operates from 115 v ac, 60 cps, single phase electricity.

The model 33N29 measures 4½ in in dia by 6¾ in in length and weighs 10 lbs.

Write in No. 441 on Reader Service Card

more on page 258



SELF-LUBRICATING
FABROID® BEARINGS
solve acute bearing problems

- Lubrication and maintenance
- Extreme temperatures
- Abrading, galling, or corrosion
- Shock and vibration
- Contamination
- Tight space, weight conditions
- Static Friction

FABROID BEARINGS PROVIDE MAXIMUM LIFE FOR LOW-SPEED, HIGH-LOAD APPLICATIONS

FABROID consists of two fused layers. The bearing layer is a weave of Teflon* fibers interwoven on the back with a layer of phenolic-impregnated glass fibers of high tensile strength.

Bonding the two layers under pressure and elevated temperature results in a dense lattice of self-lubricating Teflon fibers which have ten times the strength of other Teflon forms.

FABROID BEARINGS:

***Provide**—reliability, weight-saving, nearly-equal starting and running coefficients of friction*

***Reduce**—costs, wear, maintenance, and friction*

***Eliminate**—lubrication, fretting, brinelling, use of seals*

*E. I. Dupont's Tetrafluorethylene

U.S. Patent Nos. 2,804,886; 2,835,521; 2,885,248

SOLVE YOUR BEARING PROBLEMS WITH FABROID

PHONE (ANgeles 8-1345) or WRITE

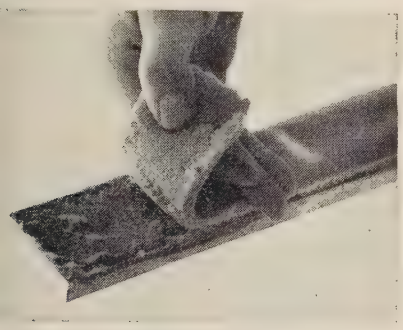
MICRO-PRECISION DIVISION
Micromatic Hone Corporation
1535 Grande Vista Ave. • Los Angeles 23, California

Write in No. 195 on Reader Service Card at start of Product Preview Section

Materials Memo

News of materiel for the aerospace industry—from the 27,000 products of the 3M Company

POT OR NOT—That's the question



e you holding off on potting of critical ctronic components because you haven't ınd a potting resin that'll take the vibra- n and the high temperature in your sys- n? Don't write off the many advantages potting before looking into "Scotchcast" R-5017, a silicone rubber foam system veloped by our ELECTRICAL PRODUCTS VISION.

"Scotchcast's" ability to absorb vibration due to its resilient but tough closed cell ucture. These closed cells also assure you maximum moisture resistance. (Water sorption after exposure for 24 hours at % RH is negligible.) As we've already plied, this material is no slouch in the h temperature regions, either. It comes ough with flying colors after extended posure to 500° F. It's equally serviceable low as −100° F. You'll find that there is problem in getting adhesion to metals, ss, and most plastic surfaces. The photo ws how the tough foam ruptures before ıd is broken. You'll be pleased to know, , that it's a room temperature curing tem—no tricky high temperature curing cautions to observe. Nevertheless, it has ample pot life of 30 minutes to permit ıring and foaming in place.

Perhaps by now you've begun thinking t this material might work equally well sealing or caulking applications. We ıd a number of others as well) feel that y, too. Let our Electrical Products Di- on representative tell you more of its iting properties.

FOR REALLY HOT COPY

Here's a material that the devil himself ght use for publication of the *Hades rald*. This new document and thermal ılation paper called "Crystal M" is com- ely inorganic and is fire resistant. Made n a special type of synthetic mica, these papers have maximum useful temperatures of almost 2000°. Valuable records printed on Crystal M paper have survived the "trial by fire" without loss of the written message.

Crystal M is an insulation that can perform with both versatility and efficiency when the heat's really on. Depending on the nature of the application and the temperature involved, the thermal K may be 0.3–1.5 Btu/hr. x sq. ft. x °F./inch. What's more, its infrared transmission is less than 3% in the region of 0 to 15 microns for a 7 mil sheet. It can easily be applied as a laminate to the surface to be protected. In this form, it offers the added dividend of acting as a fire barrier, as well as thermal insulation. Crystal M also lends itself to lamination to metal foils or can be vapor coated with metal. Such structures find ready application as light weight fire resistant blankets and drapes, or high temperature tapes. Some enterprising designers are considering it as a honeycomb material for fire resistant heat insulative curtain walls.

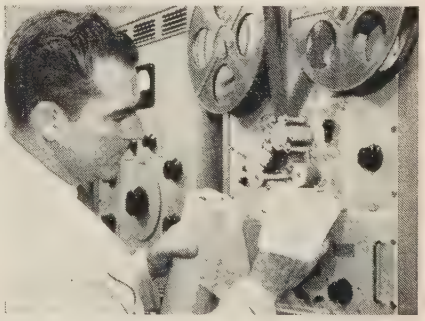
The paper either as a 100% synthetic mica composition or containing additional reinforcing fibers may be produced in calipers from 2 to 10 mils. Only papers 5 mils thick are now available for sampling. Density of the paper can vary from 0.6 to 1.7.

Other forms of Crystal M which are not yet available for sampling are light weight blocks (10 to 20 pound per cubic foot), binder free compression molded shapes and finally divided powders.

■ FOR A QUICK PICK UP...

Dust can become quite a problem—especially around precision instruments and electronic equipment. Now a new, nonwoven, scratch-free fabric—"SCOTCH" Brand Dusting Fabric No. 550—has been introduced by 3M's INDUSTRIAL TRADES TAPE DIVISION to help solve that problem.

This exceptionally thin material consists of thousands of dust-collecting pockets that



pick up and hold the dust. The fabric is formed by extra-long rayon fibres, bound together with a synthetic, odorless, unifying resin. And, since it isn't woven, there are no loose fibers or edges to unravel. Nor is the fabric oily or sticky—it has no silicones or corrosive chemicals which could remain as filmy residue on the dusted surface.

The dusters come in a 30-yard roll, perforated to make 12″ x 18″ dusters. For more information contact your 3M Industrial Trades Tape Division salesman—or use the coupon below.

■ ABOUT "MIL"

3M's Missile Industry Liaison is a service staffed by technical personnel experienced in rocket propulsion and other phases of space technology. Their job is to translate problems of the aerospace industry to those 3M specialists best qualified to solve them. If you have questions on any of the items mentioned here, or would like to know what else 3M makes—or could make—for your needs, mail coupon.

3M Company, Missile Industry Liaison – Dept. VAA-20
St. Paul 6, Minn.

Please send more information on ☐ "Scotchcast" ☐ "Crystal M" ☐ Dusting Fabric

NAME_____

FIRM_____

ADDRESS_____

CITY_____ ZONE_____

STATE_____

"CRYSTAL M", "SCOTCHCAST" AND "SCOTCH" ARE REGISTERED TRADEMARKS OF 3M CO., ST. PAUL 6, MINN.—EXPORT: 99 PARK AVE., NEW YORK 16. CANADA: LONDON, ONTARIO.

MINNESOTA MINING AND MANUFACTURING COMPANY
...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

MISSILE INDUSTRY LIAISON

Write in No. 197 on Reader Service Card at start of Product Preview Section

CHR Temp-R-Tapes are easy to apply—dependable in service.

Choose the right Temp-R-Tape for your job from a variety of types which combine some form of Teflon*, Fiberglas or Silicone Rubber backing with a silicone polymer adhesive. Temp-R-Tapes are all pressure-sensitive, even those which are thermal curing, and adhere securely to most materials, including Teflon, at extremely high temperatures. Each of these versatile tapes possess a superior combination of electrical, mechanical and physical properties suitable for a variety of applications where high dielectric strength, thermal stability, moisture resistance, durability, low coefficient of friction, non-stick properties, non-corrosiveness, non-aging characteristics or fuel resistance may be required.

TYPICAL USES:

Electrical — *slot lining; interlayer and interphase insulation; harness bundling; splicing; wrapping for microwave components, transformer coils, capacitors and high voltage cables.* Mechanical — *facings for film guides in electronic instruments, heat sealing bars, forming dies, chutes, guide rails, and for protection for metals and other materials being chemically cleaned or coated.*

AVAILABLE FROM STOCK:

¼″ to 2″ widths, 18 yd. and 36 yd. rolls and 12″ width on liner by lineal yard. Special roll widths slit to order. Temp-R-Tape is sold nationally through distributors.

FREE SAMPLE and folder — write, phone or use inquiry service.

ELECTRICAL AND INDUSTRIAL SPECIALTY TAPES

CHR CONNECTICUT HARD RUBBER CO.

*duPont TM

Main office: New Haven 9, Connecticut

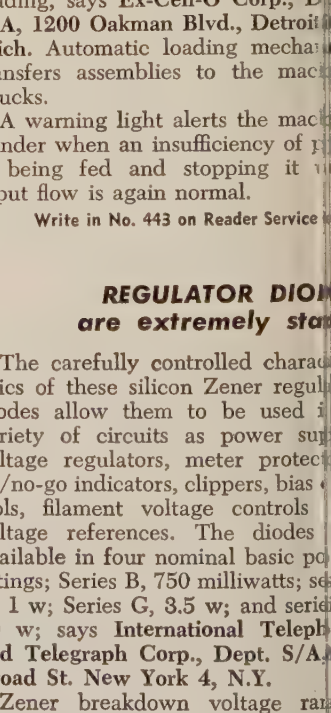
Write in No. 198 on Reader Service Card at start of Product Preview Section

ACCELEROME
is light wei

This model 2224 accelerometer designed for applications where and weight are critical. This miniature model is ½ in high, we 9 grams and provides 5 pd-mv/ sensitivity with a first resonant quency of 30KC, says **Endevco Co Dept. S/A, 161 E. California B Pasadena, Calif.**

Write in No. 442 on Reader Service

BORING MACH
is automa



This automated precision bo machine handles over 260 auto bile transmission parts every h The automatic cycle includes ass bly, loading, precision boring and loading, says **Ex-Cell-O Corp., D S/A, 1200 Oakman Blvd., Detroit Mich.** Automatic loading mecha transfers assemblies to the mac chucks.

A warning light alerts the mac minder when an insufficiency of is being fed and stopping it input flow is again normal.

Write in No. 443 on Reader Service

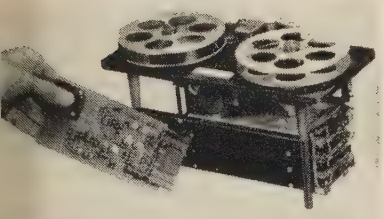
REGULATOR DIO
are extremely sta

The carefully controlled charac istics of these silicon Zener regul diodes allow them to be used variety of circuits as power su voltage regulators, meter protec go/no-go indicators, clippers, bias trols, filament voltage controls voltage references. The diodes available in four nominal basic po ratings; Series B, 750 milliwatts; s T, 1 w; Series G, 3.5 w; and seri 10 w; says **International Teleph and Telegraph Corp., Dept. S/A Broad St. New York 4, N.Y.**

Zener breakdown voltage ra cover from 3.6 v to 30 v in each po rating, making the devices suit for wide use in design of autom machinery, aircraft and missiles, c puters, communication equipment many other kinds of industrial military equipment.

Write in No. 444 on Reader Service

MINIATURE TAPE RECORDER *has 7 channels*



Model TT-100 is a miniature tape recorder with up to 7 channels of transistorized record-reproduce electronics designed for operation under severe environmental conditions, says **Precision Instrument Co., Dept. S/A, 1011 Commercial St., San Carlos, Calif.**

The features of the unit include tape speed from 0.05 to 1⅞ ips; up to 60 hours recording; ability to withstand 10 g vibration and 30 g shock, 100 per cent relative humidity, temperature range of −20 deg F to 165 deg F, 6 V d-c battery operation and tape speed accuracy up to 0.1 per cent. The unit measures 12 in by 6 in by 8 in and weighs 5 lbs.

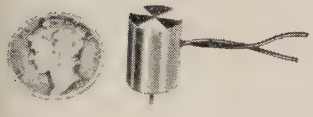
Write in No. 445 on Reader Service Card

RELAY *is microminiature*

This microminiature relay is said to guarantee 50 G vibration and 250 G shock and is gold finished. The relay, designated "Golden G," has 0.200 grid space, according to **Filors, Inc., Dept. S/A, Port Washington, N. Y.**

Write in No. 446 on Reader Service Card

ON-OFF INDICATOR *is small, light*



This on-off indicator of coil and armature construction is small, lightweight and resistant to shock, high ambient temperatures and environments. It is available with a pointer or an enclosed hermetically sealed shutter arrangement, says **Leetronics, Inc., Dept. S/A, 30 Main St., Brooklyn 1, N. Y.** The unit will operate directly on any voltage up to and exceeding 120 V at frequencies up to 500 cps without rectification and ac or dc.

It weighs 3.7 grams and withstands ambient temperatures exceeding 350 deg F.

Write in No. 447 on Reader Service Card

more on next page

Flexible temperature range
-100° F TO 500° F

COHRlastic R-10470 silicone sponge rubber sheets have a dense, uniform, non-absorbing closed cell structure highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications where resiliency at extreme temperatures is required. It may be bonded to metals, plastics, fabrics or silicone rubber. COHRlastic R-10470 possesses superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening.

COHRlastic R-10470 meets: *AMS 3195; AMS 3196; Boeing BMS 1-23; Martin–MMS C451 and MB 6103; Scintilla 9-3143; Bendix ES-0709; Douglas DMS 1597; Lockheed LAC 1-924; Minneapolis Honeywell 6384-3 and Sperry Gyroscope P.691.764 Type HTM.*

AVAILABLE FROM STOCK: in 12″ x 12″ sheets and 24″ x 24″ sheets — 1/16″ through ½″. Special thicknesses and sheet sizes up to 30″ x 30″ and 24″ x 48″ can be made to order. COHRlastic R-10470 is sold nationally through distributors.

CHR PRODUCTS INCLUDE: Airframes and engine seals, firewall seals, and coated fabrics; Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber; silicone cements; conductive gasketing; and Temp-R-Tapes — pressure-sensitive, thermal curing Teflon* Fiberglas and silicone rubber tapes.

FREE SAMPLE and folder — write, phone or use inquiry service.

Leader in Fabrication of Silicone Rubber Products
CHR CONNECTICUT HARD RUBBER CO.
**Reg. T. M. DuPont* Main office: New Haven 9, Connecticut

Write in No. 199 on Reader Service Card at start of Product Preview Section

hma

COMPLETE CAPABILITY

GSE

Now in quantity production, Horkey-Moore-designed Ammonia Servicing Trailers will help SAC's Hound Dog equipped B-52Gs guard the peace of the '60s. Designed to a new modular concept, pioneered by Wright Air Development Center and North American Aviation, GAM-77 ground support equipment like this HMA trailer lowers costs and improves airborne readiness. Here's another instance where Horkey-Moore engineering ability and production experience have been called upon for advanced, reliable ground support systems for aircraft and missiles.

hma

horkey-moore associates

24660 Crenshaw Boulevard

Torrance, California / SPruce 5-1211

Write in No. 200 on Reader Service Card at start of Product Preview Section

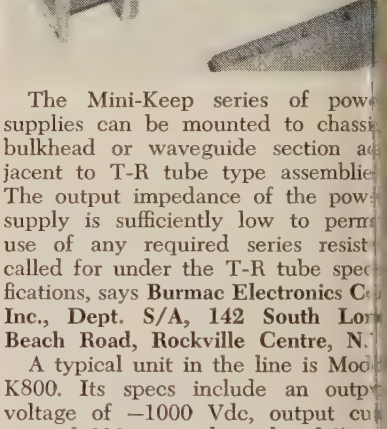
COAXIAL VALV
for exotic liquid

This coaxial dithering valve f metered liquid control will hand H_2O_2, UDMH, anhydrous hydr zinen and many of the other exot liquids, says **Eckel Valve Co., Dep S/A, 1425 First St., San Francis Calif.** The valve is said to be low weight and power consumption.

It is usually custom designed f specific applications.

Write in No. 448 on Reader Service Ca

MINIATURE POWER SUPPL
for microwave switch tub



The Mini-Keep series of pow supplies can be mounted to chassi bulkhead or waveguide section a jacent to T-R tube type assemblie The output impedance of the pow supply is sufficiently low to perm use of any required series resist called for under the T-R tube spec fications, says **Burmac Electronics C Inc., Dept. S/A, 142 South Lon Beach Road, Rockville Centre, N.**

A typical unit in the line is Mod K800. Its specs include an outp voltage of −1000 Vdc, output cu rent of 200 ma and ripple of 5 p cent peak to peak. The total volum is only about 8 cu in.

Write in No. 449 on Reader Service Ca

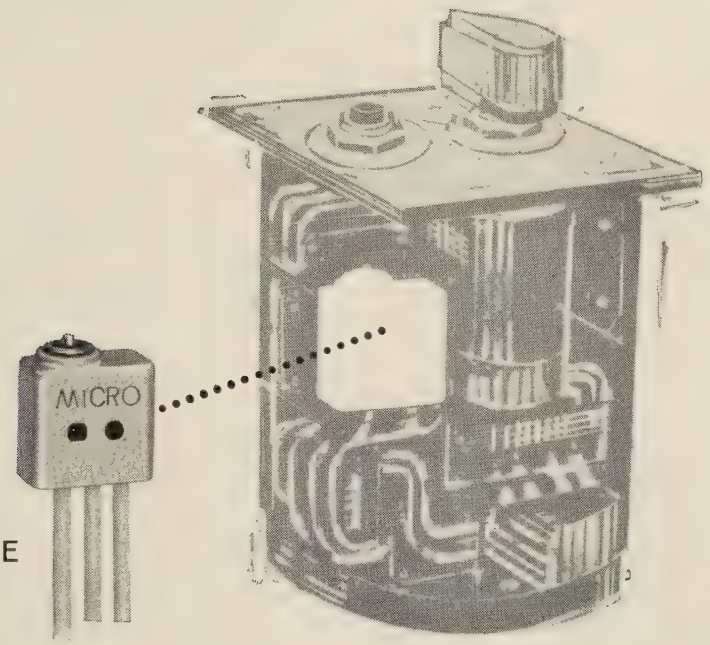
TACHOMETE
is all-electron

Two complete indicators with ove speed sensing and protective circui in a single compact package make u this all-electronic tachometer, say **Varo Mfg. Co., Inc., Dept. S/ 2201 Walnut St., Garland, Texas.** Th instrument uses a magnetic pick-up t develop an ac voltage with frequenc proportional to the rotation rate of th object being measured.

The voltage, when amplified, is fe to a detecting circuit, which produce a dc voltage to operate the indica tor. A typical instrument measure shaft, gear or rotor rotation from zer to 60,000 rpm, with full-scale accu acy of plus or minus three per cen The protective circuitry will activat a warning device at a preset value.

Write in No. 450 on Reader Service Car

more on page 26



New Sub-subminiature XE

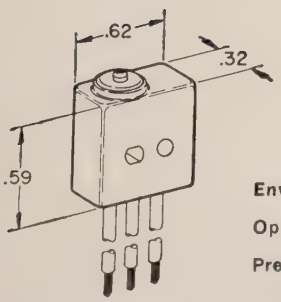
SMALLEST Environment-Sealed Switch Ever Designed

New design ideas in compact aircraft and missile devices get more "thinking room" from the MICRO SWITCH "XE", 30% smaller and 20% lighter than any previous environment-sealed snap-action switch. The precision switching unit is sealed with an elastomer seal bonded to the pin plunger and the metal housing. It is embedded in epoxy resin within a corrosion resistant, treated aluminum housing. Operation is dependable in a temperature range from —65° to 230°F, with no sacrifice in electrical capacity or precise mechanical performance.

MICRO SWITCH engineering counsel is always available to help on your particular application. Write for Data Sheet 169 or see the Yellow Pages for the nearby MICRO SWITCH branch office.

MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH Precision Switches



Environment-Sealed "XE"

Operating Force	5-17 oz.	Differential Travel	.005 max.
Pretravel	.050 max.	Overtravel	.004 min.
		Weight (without leads)	.20 oz.

ELECTRICAL RATING: 28 vdc: 7 amps., resistive; 4 amps., inductive (sea level); 2.5 amps., inductive (50,000 ft.); 24 amps., max. inrush.

Write in No. 201 on Reader Service Card at start of Product Preview Section

There's never been a filter element that could do all this

IT'S A PUROLATOR PRESSURE LOCK FILTER ELEMENT AND LOOK WHAT IT DOES:

- Gives you a filter that's absolutely free of built-in contamination
- Boosts top temperature limit of conventional stainless steel mesh filter to 1000°F or more
- Cuts 43% off the weight of an identical filter assembled by conventional bonding methods
- Significantly increases available element filtering area
- Withstands collapse pressure of more than 4500 psi
- Filters any known hydraulic fluid
- Meets requirements of specifications MIL-F-5504B and the proposed MIL-F-8815.

Only Pressure Lock will do it, and this is why:

Pressure Lock is an exclusive Purolator process of assembling a wire-mesh filter medium without welding, brazing or cementing, and without the contamination that any of these methods produce. Pressure Lock embeds the filter medium in the end caps in an absolute bond that contains no material other than the metal of the cap and filter medium. As a result, the only limitation on the performance of a Pressure Lock filter — temperature, pressure, vibration, filtration or weight — is the physical properties of the construction metals.

Present ratings are for a nominal 10 micron (absolute maximum particle size of 25 microns) and for a nominal 5 micron (absolute maximum particle size of 15 microns); in capacities of ½, 3, 6 and 12 GPM. Higher capacity elements are being processed for early production.

The Pressure Lock process provides, literally, a new standard for filter applications in aircraft and missiles, industrial hydraulics, pneumatics and chemical process industries. Fill in the coupon and send it now for further information.

Purolator Products, Inc.
Dept. 108, Rahway, New Jersey

Please send complete data on Purolator filters with Pressure Lock elements.

*Name*_____ *Title*_____

*Company*_____

*Address*_____

*City*_____ *Zone*____ *State*_____

Filtration For Every Known Fluid

PUROLATOR
PRODUCTS, INC.
RAHWAY, NEW JERSEY, AND TORONTO, ONTARIO, CANADA

Write in No. 227 on Reader Service Card at start of Product Preview Section

BENDIX FUEL NOZZLES MAKE COLD STARTING SURE

When pilots "scramble", there's no time to fool with cold start problems. That's why Bendix Fuel Nozzles are being specified on more and more jet engines—missiles and helicopters, too. Besides overcoming the cold start problem on the ground, these nozzles overcome in-flight starting difficulties after flameouts occur.

Bendix Fuel Nozzles are mass-produced out of long experience to give greater economy and dependable performance through advanced design and manufacturing processes. Today, they are used on engines powering aircraft all the way from the T-37A to the B-47.

Write for details on how Bendix Fuel Nozzles can solve your specific problem.

Bendix-Elmira

Eclipse Machine Division
Elmira, N. Y.

Bendix AVIATION CORPORATION

Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.

Write in No. 203 on Reader Service Card at start of Product Preview Section

fastest mask in the sky...

An Example of Puritan's Corporate Capability

When high altitude flight, born of the jet age, created the need for instant oxygen supply in case of emergency depressurization, Puritan's engineers created the now famous Sweep-On Mask... built for pilots. Your inquiry is invited on any problem concerning breathing systems and equipment.

Puritan
COMPRESSED GAS CORPORATION
SINCE 1913
2012 Grand Avenue Kansas City 8, Mo.

Write in No. 204 on Reader Service Card at start of Product Preview Section

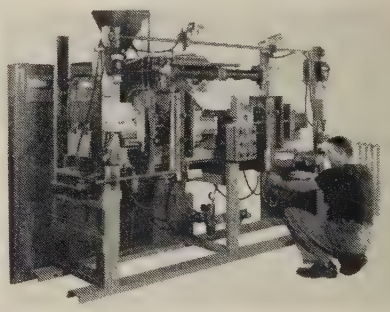
EPOXY RESIN in preweighed kit

This epoxy resin kit, designated EPY-400, is preweighed and packaged in impervious polyethylene film. The material in cured form has a heat distortion point of over 600 deg F and is non-flowing in strain gauge applications up to 400 deg F, says **Emerson & Cuming, Inc., Dept. S/A, Canton, Mass.** An exact amount is packaged for a one time use.

Resin and curing agent are separated; the user removes the separator, kneads the contents, opens the bag, and applies.

Write in No. 451 on Reader Service Card

BLOW-MOLDING MACHINE is manifold type



This blow-molding machine is a dual-manifold type, designed to handle output of any extruder within the range of 1¾ in to 3½ in. A two-way valve, operated by an air-cylinder, directs the material alternately to one end or the other, says **F. J. Stokes Corp., Dept. S/A, 550 Tabor Rd., Philadelphia 20, Pa.** It operates on 5 hp at 100 psi.

Its height is 68 in, length 102 in, width 36 in, and height to center line of extruder is 60 in. The controls are 110 V, single phase, 60 cycle.

Write in No. 452 on Reader Service Card

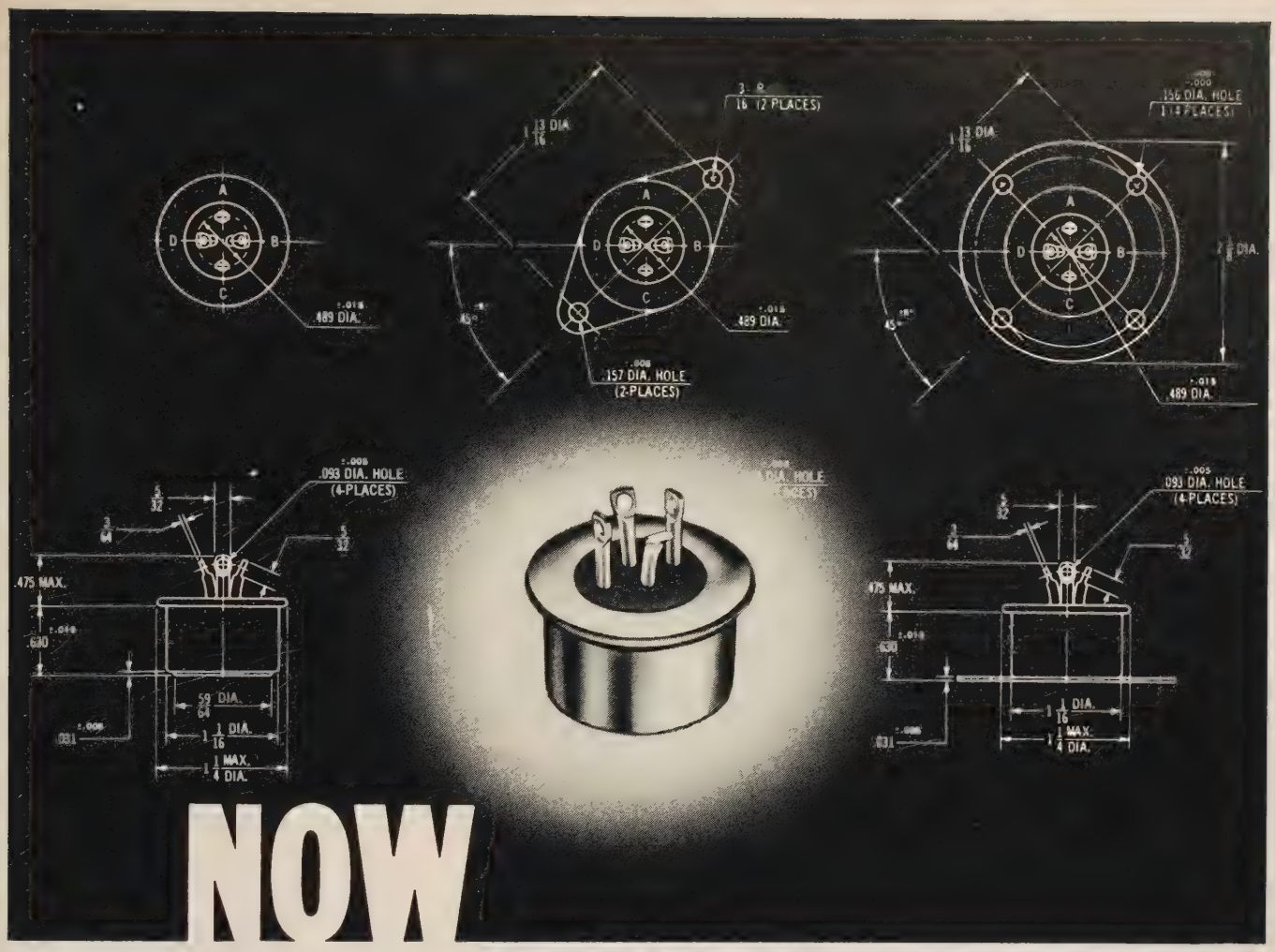
RANDOM NOISE SOURCE provides direct reading

The Mega-Node Model 240-B is an improved calibrated random noise source giving direct noise figure readings. The unit provides a choice of balanced or unbalanced output, each with several impedances: 50, 75, 150, 300 ohms and infinity, unbalanced; and 100, 150, 300, 600, ohms and infinity, balanced, says **Kay Electric Co., Dept. S/A, 14 Maple Ave, Pine Brook, N.J.**

It may be used for rapid measurement of receiver gain or noise figure without calculation of effective bandwidth and for indirect calibration of standard signal sources. The unit weighs 28 lb and measure 19¼ in. x 10¾ in. 9½ in.

Write in No. 453 on Reader Service Card

more on page 266



A THREE PHASE THERMAL SWITCH

KLIXON Hermetically Sealed 2862 Type Thermostats Solve Temperature Control Problems Reliably.

With the 2862 thermal switch you can . . .

- Switch three phase circuits directly
- Increase system reliability — through elimination of relays
- Reduce weight
- Simplify circuit design
- Eliminate contact chatter
- Obtain environmental-free switching
- Minimize radio noise
- Reduce cost

Our Field Engineers will gladly help you make test applications. Write for technical data bulletin DD-THSN-25. It gives complete performance characteristics, temperature setting information and dimensions.

SPENCER PRODUCTS

DESIGN SPECIFICATIONS*

Operating Temperature Setting	−65°F to +300°F
Operating Temperature Tolerance	open ±8°F; close ±5°F
Minimum Nominal Temperature Differential	20°F
Temperature Exposure Limits	−65°F to 325°F
Dielectric Test	1800 VAC for 1 second from all four terminals to grounded case
Electrical Rating	208/115 VAC; 60-400 cps; three-phase; 10 amps resistive; 6000 operating cycles
Vibration Resistance	MIL-E-5727-A, Procedure 1, 10-500 cps at .036" double amplitude or 10 G's
Shock Resistance	MIL-E-5727-A, Procedure II, 15 G's
Weight (Basic Unit)	approx. .0625 lb.

*Subject to change upon completion of full qualification test.

TEXAS INSTRUMENTS
INCORPORATED
METALS & CONTROLS DIVISION
3702 FOREST STREET • ATTLEBORO, MASS.

Spencer Products: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

Write in No. 205 on Reader Service Card at start of Product Preview Section

New...from MARSH!

Small solenoid valves that fill a BIG order

Conduit-type Master-mite. Grommet-type also available.

Designed to meet the need for positive-acting tight-seating valves for use on wide variety of media, including oxygen, hydrogen, acetylene, etc.

Two Types:
Conduit type and grommet type. Port sizes 1/8" and 1/4" NPT.

Ten orifice sizes:
3/64" through 1/4".

Wide range of voltages:
Standard with 115 V. A. C. but also available in 12, 24, 208, 230, 460 V. A.C.

Pressure to 540 psi.

Small, but with more strength in the Marsh manner. Coils never overheat. Entire assembly leak tight. Remarkably quiet operation. Cleanable without breaking connections. Used in any position. Bodies either brass bar stock or 18-8 stainless steel. All moving parts stainless. Underwriters' approved for use on oxygen and hydrogen and as safety valves.

Write for new bulletin

MARSH INSTRUMENT COMPANY
Dept. 43, Skokie, Illinois
Division of Colorado Oil and Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd., 8407 103rd St., Edmonton, Alberta, Canada, Houston Branch Plant, 1121 Rothwell St., Sect. 15, Houston, Texas.

Write in No. 206 on Reader Service Card at start of Product Preview Section

SELECTIVE PLATING

Production and Repair Plating
without using immersion tanks

Enables You to (1) Precision-plate selected areas economically — without disassembling components; (2) Deposit metals rapidly where conventional electro-plating is impossible or difficult. Mobile equipment takes the process to the job.

Write for Descriptive Brochure.

SIFCO METACHEMICAL, INC.
935 East 63 Street • Cleveland 3, Ohio
A Subsidiary of The Steel Improvement & Forge Co.

AGENTS

MARLANE DEVELOPMENT CO., INC. 153 East 26th Street New York 10, N.Y.
PIDDINGTON & ASSOCIATES LTD. 3219 East Foothill Blvd. Pasadena, California
OHIO METACHEMICAL, INC. 2742 Second Street Cuyahoga Falls, Ohio
D & S AVIATION CO., LTD. 671 Laurentides Blvd. Pont Viau, Montreal, Quebec

Write in No. 185 on Reader Service Card at start of Product Preview Section

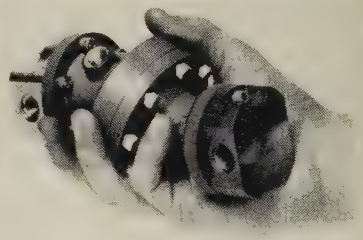
POWER SUPPLIES are miniaturized

This line of power supplies and converters are transistorized and miniaturized for airborne use. They are said to have low ripple and low output impedance. The two types are designated 150S003-2 and PS 272, says **Arnoux Corp., Dept. S/A, 11924 W. Washington Blvd., Los Angeles 66, Calif.** Weights are 13 and 16 ozs, respectively.

They meet environmental specifications of MIL-E-5272A.

Write in No. 454 on Reader Service Card

HOT-GAS MOTORPUMP for energy conversion



This hot-gas-driven motorpump departs from turbine APU designs. It is said to allow operation at moderate rotational speeds. Other features include thermal efficiency independent of operating speed and optimum hp to weight ratios in the low power ranges, 1-30 hp, according to **Vickers, Inc., Dept. S/A, Detroit 22, Mich.** It provides auxiliary power throughout a range of 0.5 hp at 1500 psi to 66 hp at 3000 psi.

Speed ratings for the integral units range from 18,200 rpm for the smallest with a displacement of 0.095 cu in/rev. to 6500 rpm for the largest with a displacement of 2.35 cu in/-rev.

Write in No. 455 on Reader Service Card

CHECK VALVES eliminate parts washout

The miniature hydraulic check valves in this line are sized to fit the envelopes of proposed specifications MS 24424 and MS 24423, and are suited to advanced aircraft and missile applications. Positive internal locking of the spring guide is featured, allowing universal application since no washout of pressed-in parts is possible, says **Parker Aircraft Co., Dept. S/A, 5827 W. Century Blvd., Los Angeles 45, Calif.**

Parts for both flared and flareless type connections are available. Sizes 4 through 16, in both stainless steel and aluminum, are qualified for type II System use, and stainless steel valves in each port configuration are suitable for Type III System use.

Write in No. 456 on Reader Service Card

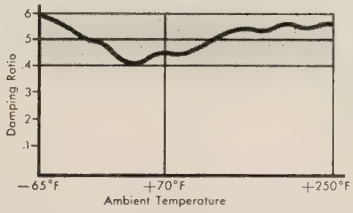
more on page 270

New Miniature Rate Gyro

Honeywell Miniature Rate Gyro
Type M-100
shown actual size

- Full Scale Range: To 400 degrees/sec.
- Linearity: Less than 0.1% of full scale to ½ range, less than 2% to full range
- Shock and Linear Acceleration: to 150G
- Size: 1" diameter, $2\frac{19}{32}$" long
- Threshold-Resolution: Less than 0.01 degrees/sec.
- Damping: 0.4 to 0.6 from −65°F to +250°F
- Vibration: 20 G to 2000 cps
- Weight: Less than 6.0 ounces

WARM-UP TIME
after motor run-up . . . ZERO!



When the chips are down and immediate action is a must, the new Honeywell Miniature Rate Gyros, Type M-100, are always ready. The typical damping of 0.6 at −65°F is obtained *without benefit of heat* from the spin motor, and is held virtually constant up to a temperature of +250°F. The gyro spin motor, requiring only 15 seconds run-up time, will operate on one (split), two, or three phase power, and is isolated from ground.

Other features of the Type M-100 include: unique quadrilever spring construction to produce greater shock and vibration capabilities than a comparable torsion bar gyro; elimination of one gimbal bearing for lower threshold; maintenance of preload throughout severe environmental conditions through exclusive spin motor construction.

Type M-100 is specifically designed for autopilot damping, radar antenna stabilization, and fire control applications. Its small size, high performance, and ruggedness suit it particularly for advanced military aircraft and guided missile applications. Write for Bulletin M-100 to Minneapolis-Honeywell, Boston Division, 40 Life Street, Boston 35, Mass.

75th YEAR
PIONEERING THE FUTURE

Honeywell

H HONEYWELL Military Products Group
SINCE 1885

Write in No. 209 on Reader Service Card at start of Product Preview Section

New Clevite Accelerometers!

500°F Operation
3% Lateral Sensitivity
50kc 1st Resonance
1600 mmfd. Internal Capacity

Stock Sizes: 5 mv/g
10 mv/g, 20 mv/g

Bulletin 9503 has the details.
Write for it today.

CLEVITE ELECTRONIC COMPONENTS

DIVISION OF
CLEVITE CORPORATION

3405 Perkins Avenue
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FIELD OFFICES

3402 West Century Boulevard
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1915 North Harlem Avenue
Chicago 35, Illinois

60 Franklin Street
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Write in No. 202 on Reader Service Card at start of Product Preview Section

The standard of performance...

Taber®

TELEDYNE®

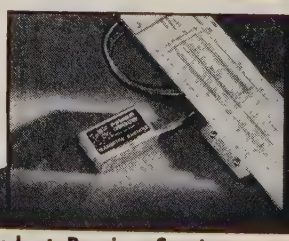
PRESSURE TRANSDUCER

Compliance to specifications so rigid as to be impossible in many pressure transducers has made TELEDYNE the "standard" for measuring pressures in rocket, missile and jet systems. Because of BONDED STRAIN GAGE construction, TELEDYNE has low sensitivity to vibration or shock in any axis. Handles extremely corrosive media, including fuming NITRIC ACID. Features Pressure Cavity clean out and standard built-in pressure overload protection. Repeatability 0.1%, Linearity 0.3%, Hysteresis 0.25%, Ambient Temperature —150° to +275° F., Pressure Ranges: 0-50 to 0-10,000 PSI. With simple cable connection, can be used simultaneously with both Taber Indicator, as shown, and standard make Recorders and Controllers.

Write or telephone for literature and prices

TABER INSTRUMENT CORPORATION

Section 36 107 Goundry St.
North Tonawanda, N. Y.
Phone: LUdlow 8900 TWX - TON 277



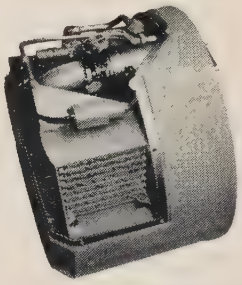
Write for literature on our complete line of Miniature Transistor Amplifiers

Write in No. 186 on Reader Service Card at start of Product Preview Section

KEEP A COOL HEAD...UAP CAN SOLVE YOUR ELECTRONIC CONTROL PROBLEM!

UAP has the specialized capabilities needed to analyze your overall problem; design the system technique; integrate components and subsystems into complete operational systems to achieve specific functions such as *temperature, mechanical* and *mass flow* control.

Example: Temperature control was assigned to UAP for the new shipboard radar tracking system developed by Sperry Gyroscope, which includes a TV Camera developed by DuMont Laboratories. Components of UAP Mechanical Refrigeration System for temperature control of TV Vidicon tube and associated electronic equipment are: condenser and evaporator, semi-hermetically sealed compressor, blower, controls and chassis. The envelope is 14″ dia. x 10″ long, with half the diameter reserved for tube circuit. Capacity of 26-pound package is 275 watts at ambient 149°F. Meets MIL environmental specifications.



U-522477 Mechanical Refrigeration System

Send us your requirements:
UNITED AIRCRAFT PRODUCTS, INC., Dayton, Ohio
(Contractual Engineering Offices: California, Gardena FA 1-4810; New York City MU 7-1283; Dayton, Ohio BA 4-3841; Canada, Montreal OX 7-0810)
WESTERN DIVISION, UAP, Inc., Gardena, California

UAP
UNITED AIRCRAFT PRODUCTS, INC.

Write in No. 210 on Reader Service Card at start of Product Preview Section

ONLY *wiancko offers a portable secondary standard with digital readout*

Check these exclusive features:

- ☑ Permits direct parameter measurements and calibration of transducers (pressure, force and accelerometers) in field, plant or laboratory.
- ☑ x2 and x4 plug-in frequency multiplier, coupled with bandwidth adjust provides greater accuracy due to increased resolution and real data capability — speedier testing and checkout.
- ☑ Readily interchangeable plug-in units for absolute, gage and differential pressure heads — ranges 5 to 10,000 psi.
- ☑ Head adapter permits use of Wiancko force rings, accelerometer or pressure pickups — 500 feet distant from Standard.

Accuracy: ±0.05 percent full scale; ranges 0-2500 psi
±0.08 percent full scale; ranges 3000-10,000 psi

For more information write for Product Bulletin 106A.

WIANCKO
ENGINEERING COMPANY

255 North Halstead Avenue • Pasadena, California

Precision with lasting reliability

Write in No. 211 on Reader Service Card at start of Product Preview Section

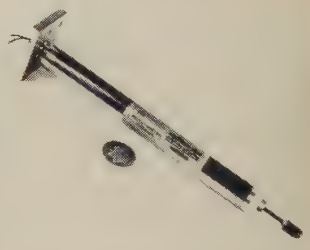
ROTATING SWIVEL *is self-aligning*

This self-alignment swivel, designed for the aviation and missile industry, has a rotating joint allowing 14 deg misalignment and 360 deg rotation. Presently supplied with AND 10056, 10057, 10058N, and MS ends, it can also be furnished with SAE, or NPT fitting ends. It can be obtained in various configurations, says **Dumont Aviation Associates, Dept. S/A, 1401 Freeman, Long Beach, Calif.** It has a standard "O" ring seal.

It is said to have been fully tested and qualified to meet MIL-J-5513-1.

Write in No. 457 on Reader Service Card

POTENTIOMETER *for missiles, aircraft*



This ½ in precision potentiometer fits inside hydraulic actuators and is suitable for exacting telemetering and control applications in missiles and aircraft. Designated the RP35 series, it is built into a stainless steel pressure-sealed case and has a stainless steel pushrod, says **Humphrey, Inc., Dept. S/A, 2805 Canon St., San Diego 6, Calif.** The all-metal construction is able to withstand temperatures from −65 deg F to 400 deg F.

The instrument is available in strokes up to 8 in. Resistance values from 500 to 20,000 ohms per inch may be built.

Write in No. 458 on Reader Service Card

POWER SUPPLY *is missile borne*

This 15 kva turbine-driven electric power generator for missiles is a thermal lag generator using its own mass as a heat sink to absorb the heat losses during its 20 min mission. It delivers 400-cycle 120/208 V, 3-phase power, according to **Bogue Electric Mfg. Co., Dept. S/A, 52 Iowa, Ave., Paterson 3, N.J.** Output voltage is regulated to plus or minus 1 per cent by a transistor-magnetic amplifier regulator. The system voltage recovers within 1 per cent of its steady state value in less than 25 milliseconds on application or removal of full load. Overshoot is less than 10 per cent.

Write in No. 459 on Reader Service Card

more on page 274

LOOK FOR THE DIAMONDS—SIGN OF FINISHING QUALITY

NOW—A Great New Combination for DOUBLE PROTECTION Against Corrosive Conditions on Aluminum, Magnesium or Zinc

IRIDITE®
CHROMATE CONVERSION COATINGS
and
IRILAC™
CLEAR PROTECTIVE COATINGS

Now, here's a fast, easy, economical way to almost double the protection against corrosion on your product. Simply follow up the IRIDITE process with a fast, easy application of IRILAC . . . and you've given your product extra protection for longer resistance to corrosive conditions, longer shelf or storage life protection from handling, and increased beauty for more attractive appearance and faster sales.

ON ALUMINUM

An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

ON MAGNESIUM

IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

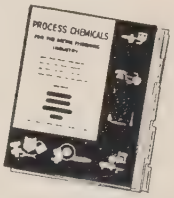
ON ZINC

IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from clear IRIDITE to olive drab, plus colored dye finishes.

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for FREE TECHNICAL MANUAL. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.



Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co.

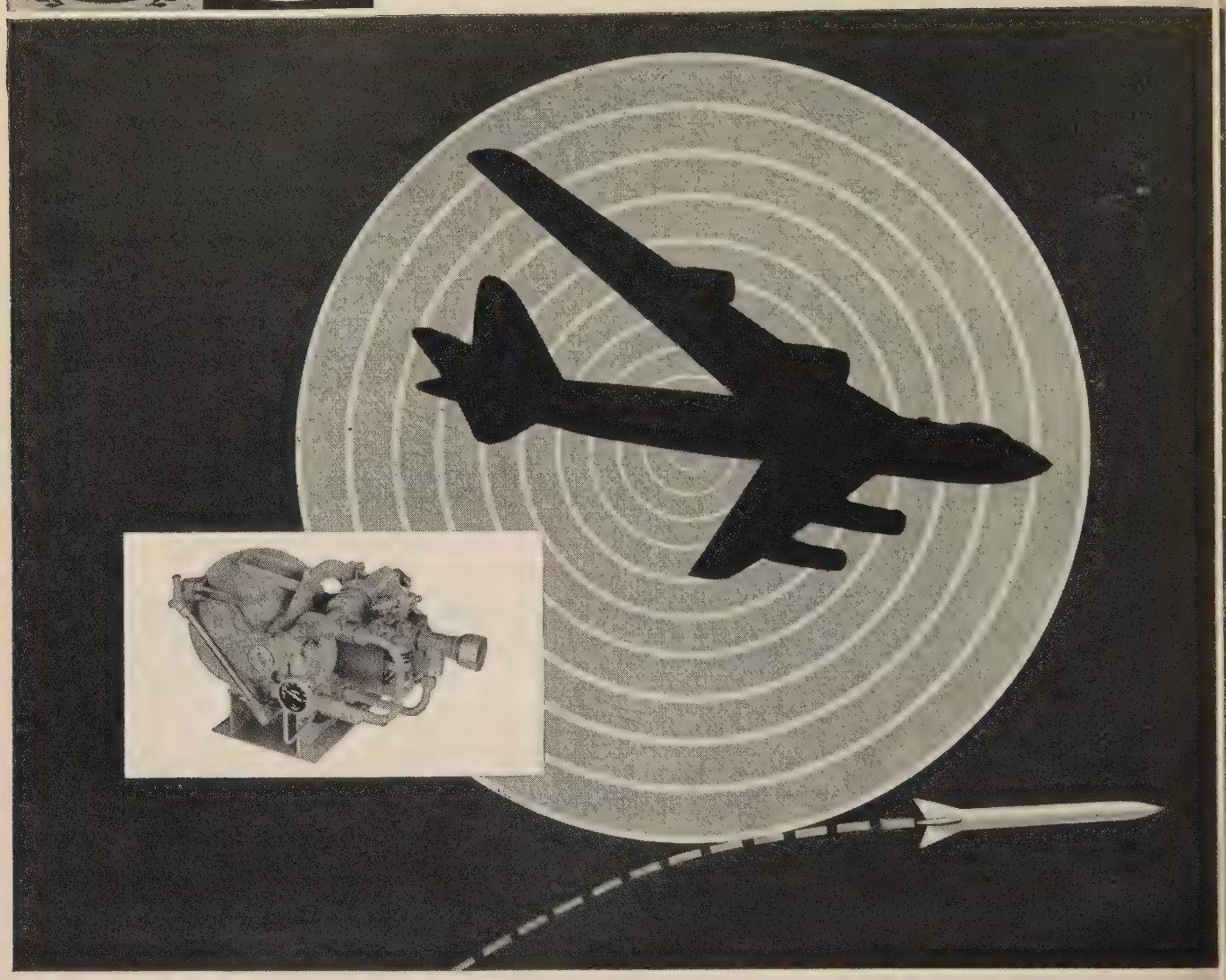
Chemical and Electrochemical Processes, Anodes, Rectifiers Equipment, and Supplies for Metal Finishing

IRIDITE® Chromate Coatings	IRILAC™ Clear Coatings	ISOBRITE® Plating Brighteners	ARP® Chemicals & Supplies	WAGNER Line of Equipment

Write in No. 212 on Reader Service Card at start of Product Preview Section

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS



HOW TO HOLD A JAM SESSION 8 MILES UP

Vickers active cooling system (inset) uses FC-75 in countermeasures system

The increasing sophistication of electronic countermeasures systems poses many problems. Among them—how to cool vital components at the environmental and operational extremes encountered in sonic and supersonic aircraft.

For the Sperry countermeasures system, a new airborne active cooling system—capable of dissipating 47KW in a 74-lb. package—was developed by Vickers using 3M Dielectric Coolant FC-75.

This most stable of all fluids offered to electronics has high electric strength of 37KV. It is self-healing, and maintains electric strength after repeated high voltage arcing. It pours at —148°F and boils at 212°F at one atmosphere . . . ideally suited for evaporative cooling.

Compatible with most materials, FC-75 is non-corrosive, non-flammable, non-toxic, non-explosive and odorless. It is thermally stable in excess of 800°F, and will not form sludges or gums under extremely rigorous conditions. These properties make it ideal as a coolant.

Investigate the remarkable properties of 3M inert fluids in terms of your own product design, miniaturization and performance problems. For free literature, write to 3M Chemical Division, Dept. KAO-20, St. Paul 6, Minn.

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

Write in No. 213 on Reader Service Card at start of Product Preview Section

ICKERS ECM COOLING SYSTEM plus

3M's FC-75 dissipates 47 kw input in 74 lb package

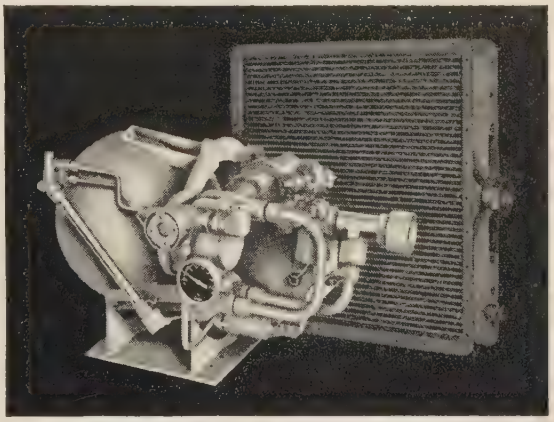
Vickers' 38 years of specializing in handling of fluids has been directed to "application-tailored" airborne cooling systems . . . reliable systems that are light weight and feature a broad range of flow and pressure characteristics.

This typical Vickers system circulates Minnesota Mining and Manufacturing Co.'s heat dissipating dielectric coolant, FC-75, through Sperry's advanced design electronic countermeasures system.

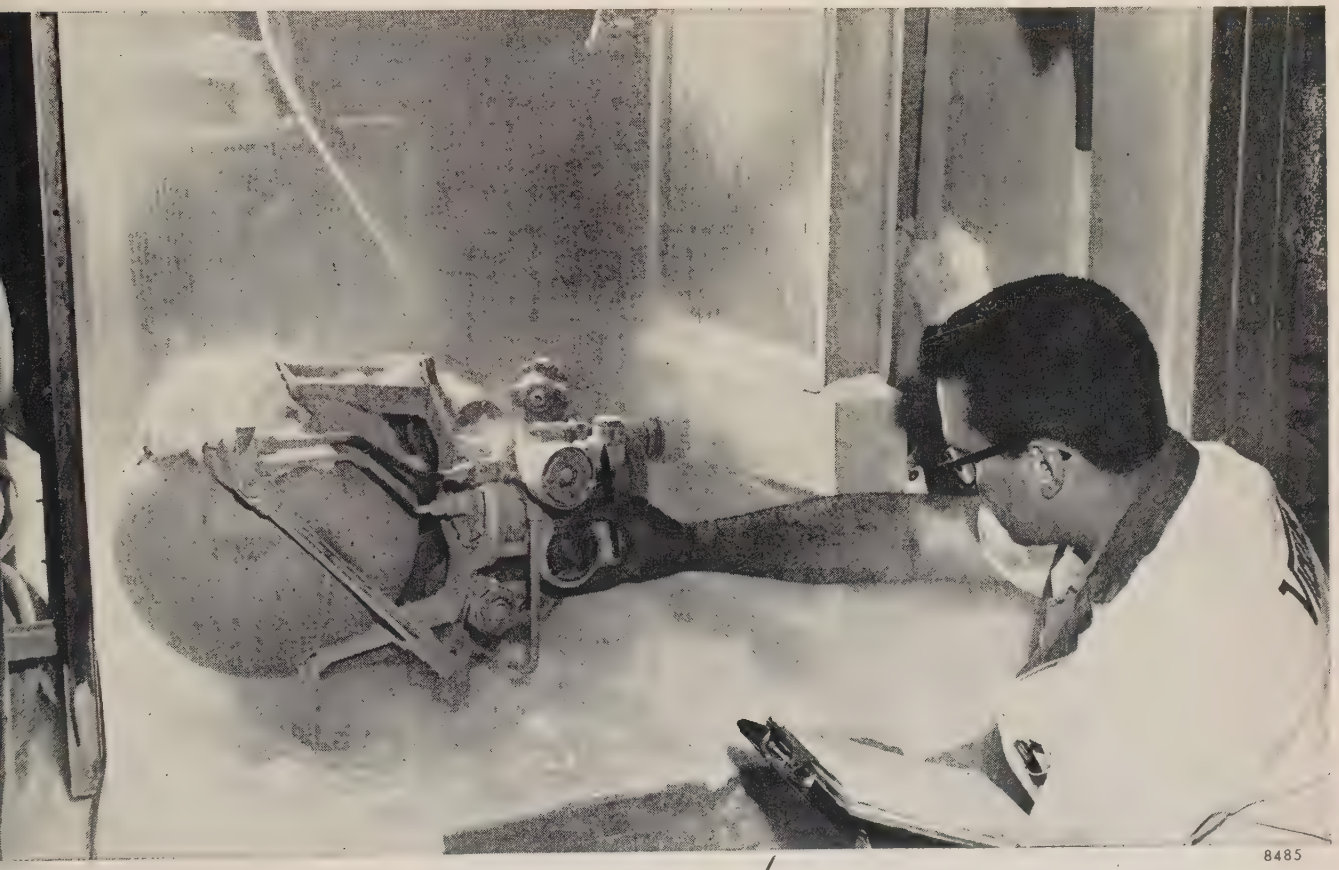
Heart of the Vickers cooling system is a single-stage, centrifugal pump that generates relatively low pressure and moves fluids at high flow rates. Because it is inherently simple in design, the Vickers pump offers high reliability and simplifies maintenance. Bearing design permits operation with fluids having low viscosities, in this instance FC-75, a fluordinated hydrocarbon.

Included in this package are safety interlocking devices for the protection of the pumping unit and ECM system. Maximum operating efficiency is assured even under unusually severe operating requirements. Such assurance stems from Vickers proven skills developed by long experience in designing and building components and systems for handling all types of fluid.

Write for Bulletin A-5244 for more details.



PUMPING UNIT AND CORE. Large airborne cooling system developed by Vickers' Aero Hydraulic Products division makes efficient use of 3M's FC-75 dielectric coolant to dissipate heat from electronic countermeasures equipment. Output pressure is required to be approximately 100 psi with fluid flow rates as high as 52 gpm. Operating range is from —65°F to 210°F. Pumping unit weighs 54 lb. dry and the heat exchanger core only an additional 20 lb. Shown below is part of the extensive testing program conducted by Vickers to prove out the new design. It included extremes of heat and cold as well as vibration, shock, attitude and other physical tests.



8485

AERO HYDRAULICS DIVISION
VICKERS INCORPORATED
DETROIT 32, MICHIGAN

division of
SPERRY RAND CORPORATION

Write in No. 214 on Reader Service Card at start of Product Preview Section

Not a worry in the world...

THIS IS ONE CRIMP THAT NEVER FAILS!

This Deutsch-designed crimp, used for Deutsch DS miniature snap-in connectors, consists of two series of four indents. It assures a crimp that is stronger than AN #18 wire itself. Special Deutsch crimping tools (manual or automatic) make the crimping simple, swift and sure.

WHAT'S MORE...Deutsch-designed tools solve the problems of inserting and removing contacts, quickly and easily.

And... just glance at these Deutsch DS connector specs:

- 7 shell sizes, with alternate clocking and insert arrangements
- exclusive Deutsch ball-lock coupling
- superior interfacial seal
- silicone inserts; no shrinkage, bonding or reversion
- temperature range −67° to in excess of 300° F
- seal before electrical contact
- interchangeable with existing Deutsch DM (MS) miniatures and hermetics
- meet all applicable requirements of MIL-C-26482

So why worry? For details on completely reliable snap-in type connectors, contact your local Deutsch representative or write for data file E-2.

© 1959 THE DEUTSCH COMPANY

The Deutsch Company
ELECTRONIC COMPONENTS DIVISION
Municipal Airport • Banning, California

Write in No. 215 on Reader Service Card at start of Product Preview Section

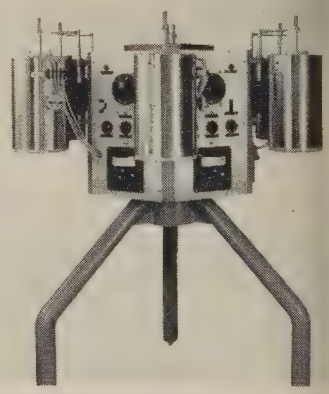
AMPLIFIER uses mechanical force

This force amplifier for measuring flow, pressure, and temperature can be actuated directly by such measuring elements, eliminating electronic amplifiers and servos. It is sensitive, rugged and flexible, says **American Meter Co., Dept. S/A, P.O. Box 309, Garland, Texas.** The device is said to develop maximum force at the balance or null position.

Input forces can be less than 1 gram (0.04 oz) and the output is precisely positioned with forces up to 500 grams (18 oz). The linear output motion is identical to the input motion within 0.001".

Write in No. 363 on Reader Service Card

ROTARY JIG for hot tensile testing



This multi-station rotary jig for hot tensile testing is for elevated temperatures and is available with 2, 4, 6 or 8 stations, with each consisting of a furnace, control system and quick-connecting pull rods, says **Arcwelder Mfg. Co., Dept. S/A, Grove City, Pa.**

Several designs of special extensometers for measuring elongation during test are also available.

Write in No. 364 on Reader Service Card

SWEEP OSCILLATOR for widths of 1000 mcps

The Magna-Sweep is an all-electronic sweeping oscillator capable of sweep widths of 1000 mc and wider. The unit operates from 5 mcps to 1000 mcps and can be modified up to 4000 mcps, says **Kay Electric Co., Dept. S/A, 14 Maple Ave., Pine Brook, N.J.**

Features include: variable center frequency; a 30cps variable sweep rate; and rf output of 0.1 V across 50 ohms and a regular sawtooth sweep output of about 20 volts. Dimensions are 21½ in by 28 in by 15 in standard 19 in rack panel

Write in No. 365 on Reader Service Card

more on page 27

Write in No. 216 on Reader Service Card

o track
trackless
pace . . .

hilco has designed and built the orld's largest 3-axis tracking antenna

world's largest 3-axis tracking antenna was recently completed at the Philco stern Development Laboratories in Palo Alto. It will be used at one of the world- e satellite tracking stations to receive vast amounts of scientific information from er space. By employing the unique design feature of tri-axial mounting, this emely accurate and complex instrument, designed and built by Philco, has com- e flexibility of movement and can provide continuous coverage of telemetered rmation and data from satellites and missiles during any phase of flight. t Philco you will find the skills that come from close association with the involved blems of planning, developing and implementing advanced space communica- s programs . . . experience that includes the design and construction of antennas nany types. Each fully meets the stringent specifications of the military and ous scientific research organizations. Philco stands ready to fill your specific needs.

LCO CORPORATION/GOVERNMENT AND INDUSTRIAL GROUP

adelphia 44, Pennsylvania

munications and Weapons Systems Division
puter Division • Sierra Electronic Division
ern Development Laboratories

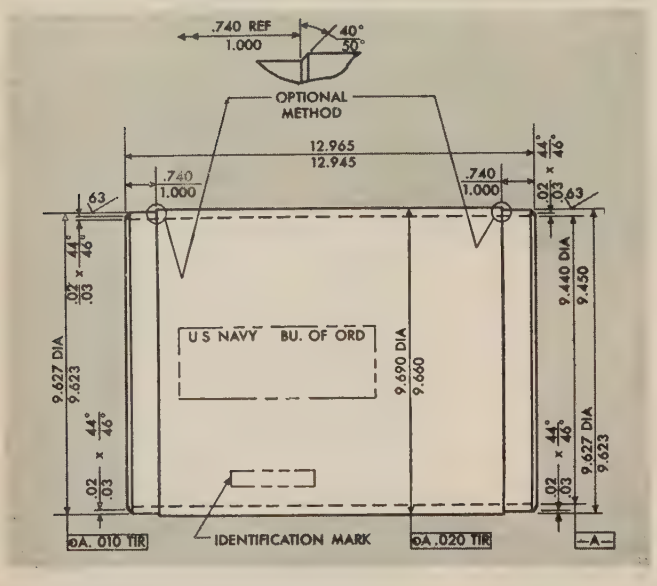
PHILCO®

Famous for Quality the World Over

This Philco 3-axis antenna stands 80 feet high and weighs over 130 tons. One of its most unique features is the 60-foot reflector—a solid aluminum skin paraboloidal structure manufactured to a tolerance of 65/1000 of an inch over its entire surface to provide maximum reception under the most severe environmental conditions. The antenna maintains its accuracy in winds up to 60 miles per hour and its mechanical efficiency in winds up to 140 miles per hour.

The Navy said

"CAN YOU"



In the drawing above, a reinforced plastic battery shell that we have made in quantity for the U.S. Navy Bureau of Ordnance. Tolerances were tight . . . such as ±.002" on this 10-1/4" dia. part, which had a wall thickness of only 3/32".

Production was successful, thanks to techniques we were already using for volume production of reinforced plastic pressure tanks.

The same techniques can solve *your* problems! Whether it's tanks or tubs or parts, call us or write. We'll tell you what's possible and whether it's practical.

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• internal pressure molding
• matched die molding
• premix molding

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TRANSDUCERS for variable pressure

These differential pressure transducers electro-mechanical sensing devices are for use in missiles, airborne and industrial applications. In 7 pressure ranges from 0-50 to 0-5000 psi, and in gage and differential types. Type PDH-4 has a sensitivity of 100 mv/v/fs and a linearity of ±1 per cent. Type PDH-4C has a 50 mv/v/fs sensitivity and is temperature compensated to 0.01 per cent/deg F., says **Crescent Engineering & Research Co., Dept. S/A, 5442 N. Peck Road, El Monte, Calif.** Weight is 16 1/2 oz.

Input voltage at 400 cps is 10 Vac optimum to 24 Vac max. Impedance is 300 ohms to 1000 ohms.

Write in No. 366 on Reader Service Card

SERVO VALVE has mechanical feedback

This mechanical feedback electrohydraulic servo valve, designated series 31 and 32, uses double nozzle flapper design with mechanical feedback from second to first stages and said to be efficient and reliable. Applications include flight control systems for aircraft and missiles and other defense and industrial control installations, says **Moog Servocontrols, Inc., Dept. S/A, E. Aurora, N. Y.**

Small quantities are available at rated flows of 1,2,4, or 8 gpm at 1000 psi valve drop.

Write in No. 367 on Reader Service Card

SMALL RATE GYRO has wide temperature range

This sub-miniature rate gyro withstands a wide range of temperature ambients from −65 deg F to 400 deg F. It is a single degree of freedom instrument intended for missiles, drones, radar antennas. Overall diameter is ¾ in, says **Telecomputing Corp., Whittaker Gyro Div., Dept. S/A, 16217 Lindbergh St., Van Nuys, Calif.** It utilizes eddy current damping provided by a permanent magnet.

The gimbal element weight and inertia are small. The rotor, mounted on high temperature spin bearings, is powered by a rapid starting hysteresis motor. Rate ranges of 10 deg/sec to 200 deg/sec are available.

Write in No. 368 on Reader Service Card

TIMING MOTORS are reversible ac types

This compact, reversible ac timing motor, suitable for military and industrial applications, has built-in gear train offering speeds from 450 rpm down to ¼ rph. Identified as 26100, the motors were designed for ease of reversing and are small size and light in weight, according to **A. W. Hayden Co., Dept. S/A, Waterbury, Conn.** Operation can be on single phase supplies.

Reversing is accomplished rapidly and conveniently with a single-pole double throw switch.

Write in No. 369 on Reader Service Card

BRAKES for motors

This miniature brake is designed for small motors and gear train housings and are available in 3 sizes ranging from 1 in O.D. to 2 in O.D., with brake torque from 10 in oz to 15 in lb, and with power consumption of from 2 to 4 watts. They can be supplied to brake either when electrically energized or de-energized, and coils are available for 6, 12, 28, 48 and 100 v dc, says **Dial Products Co., Dept. S/A, 19 Cottage St., Bayonne, N. J.**

They meet all applicable military specs covering shock, vibration, temperature, humidity, etc.

Write in No. 370 on Reader Service Card

more on page 278

Stairway to space

Sometime in the 60's, America may have a manned station in space—and it could look a lot like this scale model by Lockheed.

We have much to learn before it can be built. Research is our stairway to space—basic research that seeks to discover the new rather than develop the known. We cannot predict what such research will discover, or when—but we delay it or curtail it at our peril.

Today, at Lockheed's Missiles and Space Division, more than 5,000 scientists and engineers are engaged in one of U.S. industry's broadest research and development programs. One group is conducting private industry's largest, most diversified program of fundamental research in space physics. Already they have made massive contributions to America's space technology—particularly in the Discoverer, MIDAS, and Samos satellite programs of the U.S. Air Force.

LOCKHEED MISSILES & SPACE DIVISION

Check Employment Inquiry Form on Page 161

AIR COMPRESSOR for ground support

This portable air compressor assembly for aircraft and missile ground support, test and checkout, provides dry, compressed air at a regulated delivery pressure from 0 to 3000 psi. It is safe for use on tires and low pressure receivers, says the **Cornelius Co., Aero Div., Dept. S/A, 550 39th Ave. N. E., Minneapolis 21, Minn.** Capacity of model 130R3500 is 2 cu ft per min of free air at 3000 lb per sq in. Operating speed is 4100 rpm.

Compressor is operated with a 200 V, 400 cycle, 3-phase power source supplied by an auxiliary power unit. Weight is 93 lb. Case dimensions are 16x18x21 in.

Write in No. 371 on Reader Service Card

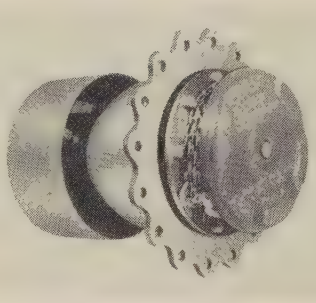
DC MOTOR has rectangular frame

This 28v dc light weight motor has a rectangular type frame for operation on dc power sources. It delivers 0.50 hp at 12,500 rpm, continuous duty, and 1.0 hp at 9,000 rpm, intermittent duty, says the **Hoover Electric Co., Dept. S/A Hangar Two, Port Columbus, Columbus 19, Ohio.** It is 6.625x3.470x4.250 in high.

It weighs 5.6 lbs and is explosion proof.

Write in No. 372 on Reader Service Card

REFUELING VALVE is remote-controlled



This refueling valve, No. 42-1755-000, is readily adaptable to unusual flow rates and to handle exotic and high energy fuels and other fluids. It is built to handle a flow rate of 200 gpm with an operating pressure of 50 psi, says **Aero Supply Mfg. Co., Inc., Dept. S/A, Corry, Pa.** Operating temperature ranges from −65 deg F to +160 deg F, fuel and ambient.

The valve operates from a remote servo valve.

Write in No. 373 on Reader Service Card

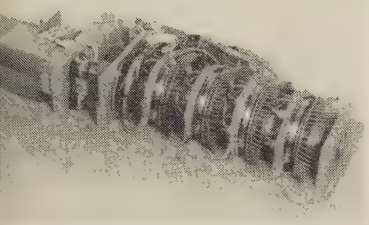
POLYESTER FILM is readily cold-formed

A laminated polyester film with excellent flexibility and mechanical strength, good electric properties, high heat resistance to delamination is announced by **Mica Insulator, Dept. S/A, Schenectady, N. Y.** The sheet consists of two plys of 0.010 in thick polyester film, said to be laminated with a special bonding agent.

The laminate can be cold formed readily with wooden molds or punched into shapes and forms. It can be repeatedly creased or bent without cracking, breaking or delaminating.

Write in No. 374 on Reader Service Card

PRESSURE SCANNER
cuts transducers

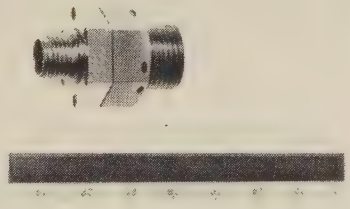


Up to 160 individual pressures can e read with only 16 transducers ith this pressure scanner, known as P-105. It is designed for wind tun-el applications in which up to 10 ressures can be scanned by each of 6 transducers of a 16-channel sys-m, and can be used in any pressure strumentation system, says **Datex orp., Dept. S/A, 1307 S. Myrtle ve., Monrovia, Calif.** It consists of rotors, 4 stators, a motor, switching echanisms, and electrical and pres-re connections.

Each of the 4 rotors has provision r mounting 4 flush-diaphragm trans-ıcers.

Write in No. 375 on Reader Service Card

TRANSDUCER
is oil-damped



This miniature pressure transducer developed for use in rocket engine test environments is oil damped and withstands the violent pressure transients generated in shock tubes or transmitted from firing chambers, says **Statham Instruments, Inc., Dept. S/A, 12401 W. Olympic Blvd., Los Angeles 64, Calif.** In addition the high natural frequency of undamped miniature flush-diaphragm instruments is retained.

The P285TC measures pressures from 0-50 to 0-1000 psi with the operational, environmental and service life advantages, it is said, of unbonded strain gage transducer.

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WHITTAKER GYRO: Leading designer and manufacturer of electromechanical and non-electric gyroscopes, including rate gyros vertical gyros, and position gyros. In addition, this Division is active in the sub-systems field with stable platforms, inertial guidance equipment, and auto pilots for missiles.

MONROVIA AVIATION: Producers of precision aircraft structural assemblies, Monrovia Aviation's products are installed on America's principal military and commercial jet aircraft. This Subsidiary also designs and manufactures customized portable air conditioning units for missile ground support purposes.

TELECOMPUTING SERVICES: Skilled in the establishment and operation of data processing centers, primarily for military and civil agencies of the Government. At White Sands Missile Range, TSI processes and analyzes missile test data. At Vandenberg AFB, this Subsidiary provides data processing services for SAC's 1st Missile Division.

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DATA INSTRUMENTS: Leading designer and producer of data reduction systems for ground support and range instrumentations. Product line includes shaft rotation digital equipment, decommutators, and other highly complex and specialized instruments for missile and aircraft testing, telemetering and in-flight operation.

ELECTRONIC COMPONENTS: Designs and produces components, including magnetic amplifiers, transformers, micro-miniature relays, delay lines and high temperature ceramic capacitors. These reliable components are being selected for installation in many of the country's principal missile and space programs.

COOK BATTERIES: Designers and manufacturers of automatically and manually activated silver zinc batteries for specialized missile application. These auxiliary power units provide primary or secondary electrical power. This subsidiary also produces power conversion and other electronic apparatus.

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data preview

TARGET DATA—The Model 68 cartesian-to-polar coordinate converter, which accepts target coordinates in the form of three dc voltages, has been described in an information sheet by **Milgo Electronic Corp., Dept. S/A, 7601 N. W. 37th Ave., Miami 47, Fla.** The unit provides output data on azimuth, elevation and slant range of the target.

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COORDINATE CONVERTER—A polar-to-cartesian coordinate converter that operates in conjunction with range, azimuth and elevation potentiometers of a radar to produce X, Y, and Z target coordinates has been briefly described in a release prepared by **Milgo Electronic Corp., Dept. S/A, 7601 N. W. 37th Ave., Miami 47, Fla.** Accuracy of the Model 67 is such that maximum error in the output is under .02 per cent of full range.

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PLOTTER—A data sheet on the Model 1509 digital plotting system for the conversion of digital data to analog data has been issued by **Milgo Electronic Corp., Dept. S/A, 7601 N. W. 37th Ave., Miami 47, Fla.** The system, a modification of which is currently in use at a missile test center, incorporates four X-Y recorders, and is designed to operate in conjunction with an IBM 704 or 709 digital computer.

Write in No. 379 on Reader Service Card

DIESEL ENGINES—Three bulletins that give a comprehensive picture of Diesel, gas and dual-fuel engines for industrial and other purposes are available from **White Diesel Engine Div., The White Motor Co., Dept. S/A, Springfield, O.** Bulletin 115 references bulletins that describe the six basic engines and the 19 available models. Bulletins 110 and 111 give detailed information on three models of stationary, four-cycle Diesels with maximum ratings of about 2100 bhp.

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CIRCUIT BREAKERS—The Type FB high-speed dc circuit breakers, which are available in ratings from 1200 through 12,000 amps continuous current at 1000 V dc, have been described in the four-page Bulletin S-4601-1A by **I-T-E Circuit Breaker Co., Dept. S/A, 1900 Hamilton St. Philadelphia 30, Pa.** Design features, performance, applications, ratings, dimensions, and weights are considered.

Write in No. 381 on Reader Service Card

GENERATING PLANTS—A thorough review of both mobile and stationary Diesel generator plants in a variety of sizes in contained in a file compiled by **White Diesel Engine Div., The White Motor Co., Dept. S/A, Springfield, O.** Among the mobile units are those rated for 350, 500, 1000 and 1250 kw.

Write in No. 382 on Reader Service Card

CAPABILITIES—An extensively illustrated 40-page booklet has been prepared to outline the capabilities of **Aviation Divisions, Kelsey-Hayes Co., Dept. S/A, Detroit 32, Mich.** Products illustrated include a variety of aircraft and missile components, and facilities information covers hydraulic presses and other heavy machinery.

Write in No. 383 on Reader Service Card

ELECTRIC CLIPS—A complete line of solid copper and cadmium-plated steel electric clips and companion insulators has been described in the eight-page Catalog 220 by **Mueller Electric Co., Dept. S/A, 1578B E. 31st St., Cleveland 14, O.** Types range from miniaturized clips to welding ground clamps.

Write in No. 384 on Reader Service Card

PLASTICS—Seven flameproofed diallyl phthalate plastic molding compounds for electrical and electronic use are covered in a four-page specification sheet available from **Mesa Plastics Co., Dept. S/A, 12270 Nebraska Ave., Los Angeles 25, Calif.** In addition to high flame resistance, the compounds exhibit rapid flame-out characteristics.

Write in No. 385 on Reader Service Card

PLANT CONTROL—Full-scale automatic control in industrial plants is the subject of a four-page bulletin published by **Consolidated Systems Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** The design of several systems, including that of an analytical system, is discussed.

Write in No. 386 on Reader Service Card

TUBE FITTINGS—A four-page catalog on Vari-Grip tube fittings for glass and metal tubing has been released by **Harold Kruger Instruments, Dept. S/A, P. O. Box 164, San Gabriel, Calif.** The connectors are designed so that only Teflon surfaces are in contact with reactive liquids and gases passing through the tubing.

Write in No. 387 on Reader Service Card

DRY LUBRICANTS—Factors to be considered in the use of solid film dry lubricants to permit maximum performance have been outlined in a 20-page pocket-size booklet published by **EverLube Corp., Dept. S/A, 6940 Farmdale Ave., North Hollywood, Calif.** Advantages of dry lubricants are reviewed, along with the roles of base materials, mechanics, and environment.

Write in No. 388 on Reader Service Card

SPRING CLUTCHES—Five standard lines of spring clutches designed for use in machinery, equipment and instrument applications utilizing drives up to five hp have been described in a 30-page catalog by **Marquette Div., Curtiss-Wright Corp., Dept. S/A, 1145 Galewood Dr., Cleveland 10, O.** The clutches come in ⅛ to one-in bore sizes and with torque capacities of up to 1250 lb-in.

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CORROSION—Bulletin 7102, a six-page folder that considers the several ways in which wear by fretting corrosion can be controlled has been issued by **T. B. Wood's Sons Co., Dept. S/A, Chambersburg, Pa.** This type of corrosion begins with the wear between two members under pressure and moving microscopically relative to each other.

Write in No. 390 on Reader Service Card

TEST FACILITIES — The six-page Bulletin 5902 has been issued to describe the facilities and services for analysis, development, research, and product and material inspection provided by **United States Testing Co., Inc., Dept. S/A, 1415 Park Ave., Hoboken, N.J.** Company services include metallurgical studies, plastics evaluation, and physical testing, among many others.

Write in No. 391 on Reader Service Card

LOW TEMPERATURE RESEARCH—Technical data on a variety of developments in the field of ultra low temperature have been compiled in a 44-page book, published by **Hofman Laboratories, Inc., Dept. S/A, 5 Evans Terminal, Hillside, N. J.** Topics covered include low temperature chemistry, solid state physics, superconductivity, metallurgical research, and maser research, as well as the application of cryogenic equipment in low temperature research.

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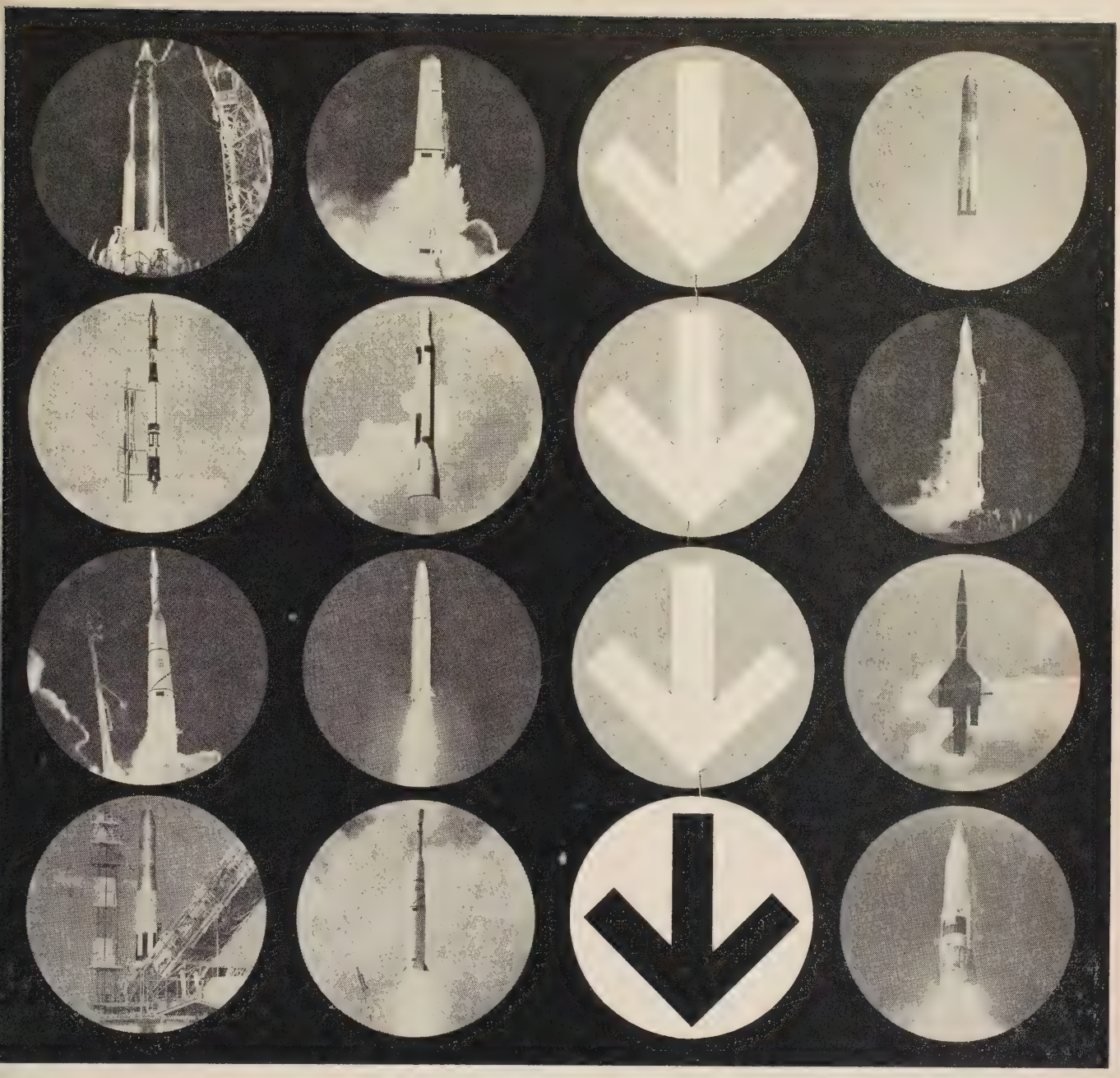

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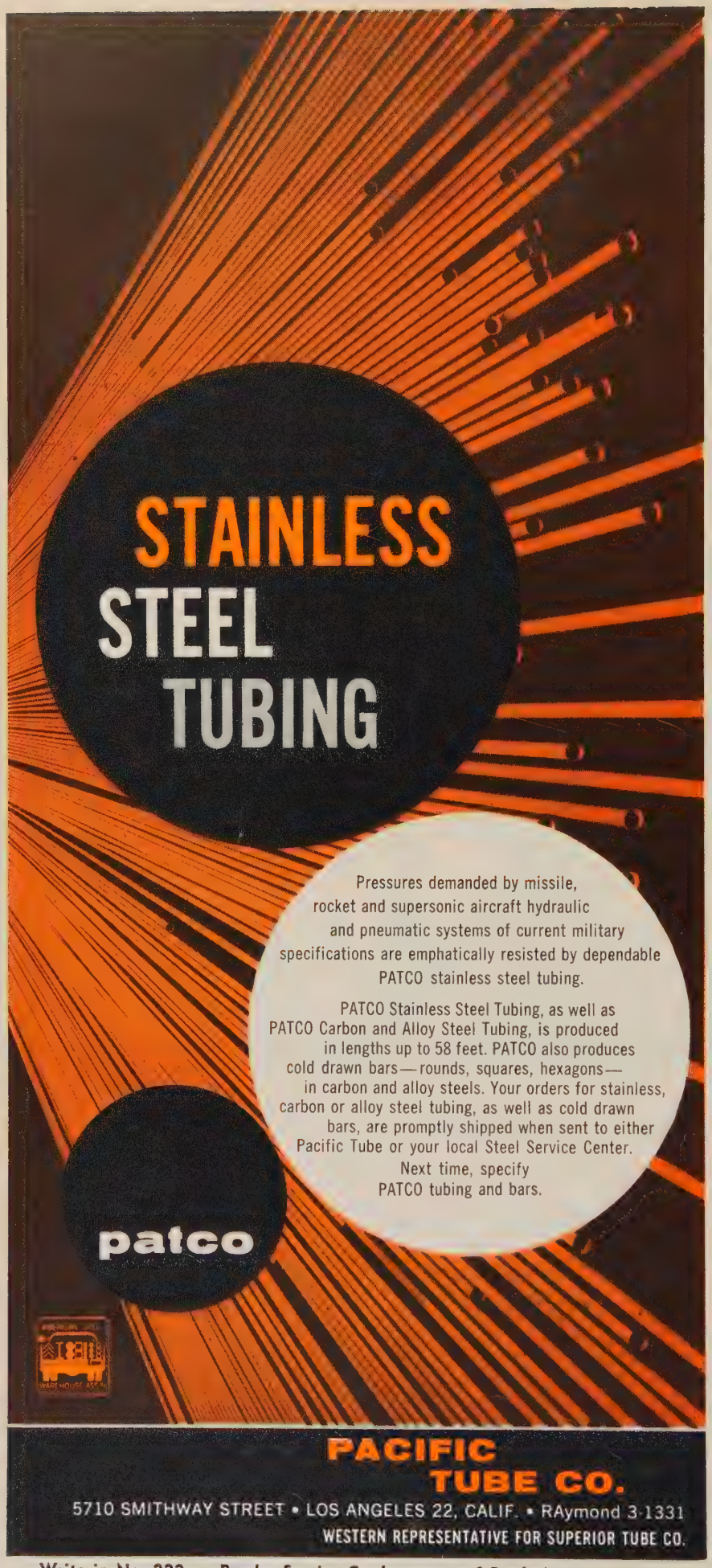
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DATA PREVIEW

WELDING—An eight-page guide to the selection of arc welders for use with the stick electrode, gas-shielded tungsten arc or gas-shielded metal-arc welding processes has been prepared by **Air Reduction Sales Co., Dept. S/A, 150 E. 42nd St., New York 17, N. Y.** Form ADR 121 assess such factors as location of the operation, machine characteristics, welding power, and welding duty cycle.

Write in No. 393 on Reader Service Card

CONNECTORS—External power connectors used in aircraft and missile ground support have been described in the 28-page Catalog 66 by **Albert & J. M. Anderson Mfg. Co., Dept. S/A, 289-305 A St., Boston, Mass.** The publication covers molded rubber cable assemblies and mating receptacles as well as a line of detachable plugheads for attachment to cable in the field.

Write in No. 394 on Reader Service Card

OVEN—A high-temperature bench-model oven that offers constancy and uniformity over a 125 to 1000-deg F range has been described in Bulletin 2321 by **American Instrument Co., Inc., Dept. S/A, 8030 Georgia Ave., Silver Spring, Md.** The unit has a four-cu ft work space, is equipped with two adjustable wire shelves, and will heat up to maximum in 3½ hrs.

Write in No. 395 on Reader Service Card

PANEL INSTRUMENT—A 24-page catlog on panel instruments for commercial and military applications has been made available by **Federal Pacific Electric Co., Dept. S/A, 50 Paris St., Newark 1, N. J.** Bulletin 3-15 covers ac and dc meters, elapsed time meters, aircraft instruments, shunts, and current transformers.

Write in No. 396 on Reader Service Card

SERVO AMPLIFIERS—Information on three new servo amplifiers designed for continuous operation over a range of −55 to +125 deg C has been released by **Electronics Div., Bulova Watch Co., Dept. S/A, Woodside 77, N. Y.** Power output of the Amp 576, Amp 424-6 and Amp 424-12, which are basic 3-, 6- and 12-W units, respectively, depends on the size motor with which they are used.

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SHAFT SEAL—Information on an all-metal, bellows-type mechanical shaft seal for aircraft, missile, rocket and other uses is available from **Turbocraft, Inc., Dept. S/A, 492 E. Union St., Pasadena, Calif.** The Series AMB seal operates effectively at pressures up to 1000 psi, speeds up to 36,000 rpm, and over a −400 to +1000-deg range.

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more on page 285

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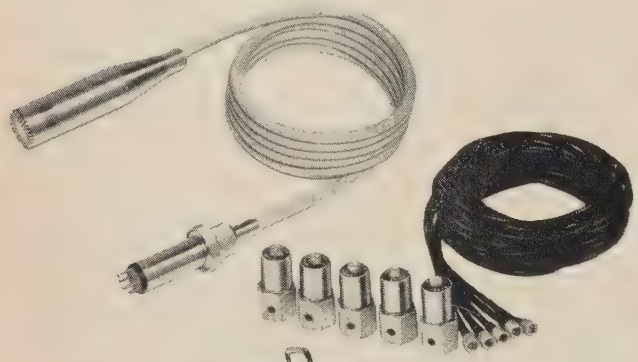

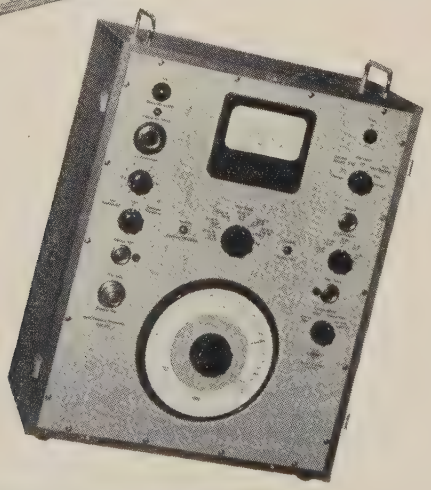

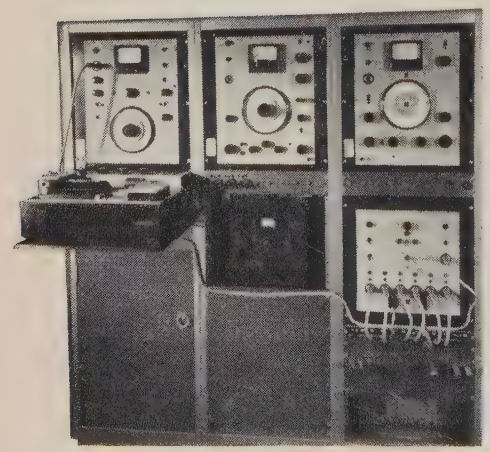

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Dynamic Range: 0.002G to 2000G
Frequency Range: 10 c/s to 25,000 c/s
Read Out: TRUE RMS, Average or Peak on Meter or Chart Recording
Accuracy: ± 0.5 db

AUDIO SPECTRUM ANALYSIS INSTRUMENTATION

Voltage Range: 5 micro volts to 1000 volts
Frequency Range: 10 c/s to 35,000 c/s
Filter Band Widths: 6% to 30%, ⅓ octave; full octave
Tuning: Manual or Automatic
Read Out: TRUE RMS, Average or Peak on Meter or Calibrated Chart
Accuracy: ± 0.5 db

FREQUENCY RESPONSE MEASURING INSTRUMENTATION

Frequency Ranges: 2 to 2000 c/s, 20 to 20,000 c/s, 200 to 200,000 c/s
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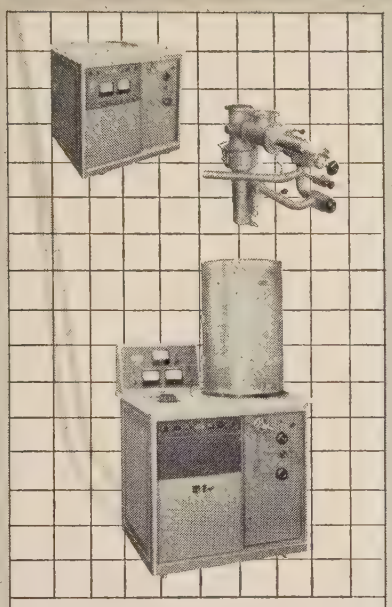

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Buy exactly what you need, from basic plumbing to complete Evaporators and Bakeout Systems. Incorporate additional equipment as your requirements grow.

TROUBLE-FREE PERFORMANCE:
Each VE-400 System undergoes a full week (168 hrs.) of test run and inspection before shipment.

FREE "400" SERIES BROCHURE contains complete performance data and design specifications on the 4" building block components and modular systems. Write Department A-1436.

Veeco VEECO VACUUM CORP.
86-M Denton Avenue, New Hyde Park
Long Island, New York
HIGH VACUUM & LEAK DETECTION EQUIPMENT

Write in No. 225 on Reader Service Card

DATA PREVIEW

AC GENERATORS—Nine specification sheets covering 18 models of its standard line of ac generators has been prepared by **Kato Engineering Co., Dept. S/A, Mankato, Minn.** Dimensions and drawings are included for the units, which range from one to 250-kw types.

Write in No. 399 on Reader Service Card

PLASTIC DIES—Engineers, product designers and others involved in the use of extruded plastic parts in either custom profile or hard and soft sheet form may be interested in a four-page brochure available from **Conneaut Rubber & Plastics Co., Dept. S/A, Shop & Commerce Sts., Conneaut, O.** The publication lists the standard stock and dies available and includes silhouettes of the many die shapes.

Write in No. 400 on Reader Service Card

PRESSURE PICKUP — Bulletin 1620, describing the Type 4-326 pressure pickup, which is capable of absolute and gage measurement to 10,000 psi, is available from **Consolidated Electrodynamics Corp., Dept. S/A, 360 Sierra Madre Villa, Pasadena, Calif.** The pickup permits external adjustment for temperature compensation, sensitivity, and bridge balance.

Write in No. 401 on Reader Service Card

METAL CORROSION—The corrosion resistance of Zirconium, titanium, tantalum, Hastelloy C and Stainless 316 tubing to 43 commonly encountered reagents has been compared in a wall chart prepared by **Damascus Tube Co., Dept. S/A, Greenville, Pa.** The chart's ratings extend from "Excellent" for less than three mils per year to "Not Recommended" for over 50 mils per year.

Write in No. 402 on Reader Service Card

HIGH-STRENGTH STEEL—A technical data brochure on two high-strength, high-temperature steels for critical structural applications in airborne vehicles has been prepared by **Universal-Cyclops Steel Corp., Dept. S/A, Station St., Bridgeville, Pa.** Information on the steels, Unimach I and Unimach II, covers heat treatment, and physical and mechanical properties.

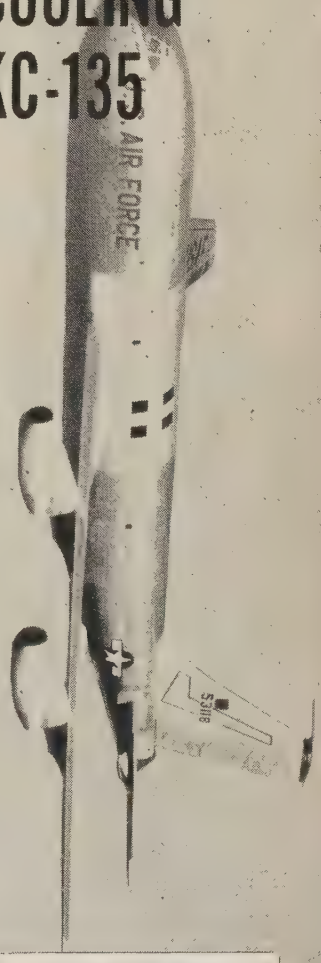
Write in No. 403 on Reader Service Card

ISOLATORS—The factors to be considered in the selection of shock and vibration isolators have been outlined in the four-page Bulletin 59-04 by **Barry Controls, Inc., Dept. S/A, 700 Pleasant St., Watertown 72, Mass.** The bulletin analyzes a vibration isolation problem with the aid of graphs, and illustrates typical isolation devices.

Write in No. 404 on Reader Service Card

more on page 287

JOY FANS
FOR
DOPPLER BAY
COOLING
KC-135



Fan No. X702-218A
Supplies 90 cfm
at 6.25" WGPs
0.15 hp

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Joy Manufacturing Company
Oliver Building • Pittsburgh 22, Pa.

Write in No. 226 on Reader Service Card

Have you gotten our letter about this test set ?

Transistorized . . . programmed with perforated tape — this set is a versatile means for testing drone radio command guidance systems. Its automatic features are typical of test and checkout equipment produced by Chance Vought's Electronics Division. These people have provided GSE support for radar and inertial guidance; flight stabilization; warhead arming and fuzing; rocket engine and telemetering systems. Altogether, over 4,500 articles of GSE equipment have been delivered in these and other programs.

This capability is available to the company or service that needs it. A recent letter from Vought Electronics describes experience, labs and representative products in detail. It was mailed to military agencies and weapons developers—primarily to guidance system developers.

If you haven't received this letter . . . if you want to know more about an experienced source of GSE support for small and large jobs, write:

VOUGHT ELECTRONICS

A DIVISION OF CHANCE VOUGHT AIRCRAFT, INCORPORATED • DALLAS, TEXAS

GROUND SUPPORT ELECTRONICS • ANTENNAS • POWER CONTROLS

Write in No. 228 on Reader Service Card at start of Product Preview Section

DC INVERTERS—Miniature airborne instrumentation dc inverters designed to provide ac power for rate and directional gyros, where frequency regulation is of prime importance have been described in Bulletin E3A by **Gulton Industries, Inc., Dept. S/A, 13041 Cerise Ave., Hawthorne, Calif.** The transistorized units meet MIL-E-5272 specifications in ambient temperatures from —65 to +160 deg F.

Write in No. 460 on Reader Service Card

MICA INSULATION—The Micabond of bonded mica insulation has been described in a 16-page revised catalog issued by **Continental-Diamond Fibre Corp., Dept. S/A, Newark, Del.** "CDF Micabond" covers grades, forms, sizes, weights, specifications, types of backings, and bonding materials, as well as notes on fabricating techniques.

Write in No. 461 on Reader Service Card

METAL CLEANING — "Some More Good Things to Know About Metal Cleaning" is the title of a 28-page handbook published by **Oakite Products, Inc., Dept. S/A, 152C Rector St., New York 6, N. Y.** Among topics discussed are tank cleaning, electrocleaning, ultrasonic cleaning, rust prevention, paint stripping, and deoxidizing and metal-etching treatments.

Write in No. 462 on Reader Service Card

JIG BORERS—A line of end-measure jig borers and accessory equipment has been thoroughly described in Circular 614, a 28-page brochure available from **Pratt & Whitney Co., Inc., Dept. S/A, Charter Oak Blvd., West Hartford, Conn.** The equipment can provide locating, boring and checking accuracy to .0001 in with high speed and ease of operation.

Write in No. 463 on Reader Service Card

RELAYS & SOLENOIDS—A 44-page illustrated catalog lists and descirbes many relays, steppers, sensitrols, solenoids, contractors, rectifiers and related items, prepared by **Universal Relay Corp., Dept. S/A, 42 White St., New York 13, N.Y.** Most items shown are carried in stock in production quantities.

Write in No. 464 on Reader Service Card

ENVIRONMENTAL FACILITIES—Capabilities for the isolation and reproduction of a wide variety of environmental characteristics are described in a brochure issued by **General Electric Co., Missile and Space Vehicle Dept., Dept. S/A, Room 4A, 3198 Chestnut St., Phildelphia 4, Pa.** It includes conditions of vibration, with varying temperatures and altitudes, humidity, tension and compression, shock, acoustics, acceleration, and pressure.

Write in No. 465 on Reader Service Card

DEEP-DRAWN PARTS—Basic information on the deep drawing process, which is applicable to the production of rocket and missile components, has been issued in Bulletin 70 by **Pressed Steel Tank Co., Dept. S/A, 1445 S. 66th St., Milwaukee 14, Wisc.** Topics covered include the metals used, formation of parts, and the effect of deep drawn parts on product improvement, production speed, and costs.

Write in No. 405 on Reader Service Card

ALUMINUM TUBES—A 48-page book that is reported to be one of the most detailed presentations of data on aluminum tubes has been published by **Revere Copper and Brass, Inc., Dept. S/A, 230 Park Ave., New York 17, N. Y.** Included is comprehensive information on the selection of proper tube alloys, temper designations, and alloy resistance to chemicals, as well as details on seamless tube, extruded tube and pipe, welded tube, and other tube types.

Write in No. 406 on Reader Service Card

CLUTCH—A data sheet on the C-18 magnetic clutch, a device with an electromagnetic design and with up to 400 per cent more output torque than conventional clutches of comparable size, has been issued by **Guidance Controls Corp., Dept. S/A, 110 Duffy Ave., Hicksville, L. I. N. Y.** Included are general specifications and average characteristics of the clutch, which has applications in computers, controls and servomechanics.

Write in No. 407 on Reader Service Card

BATTERIES—A technical brochure on Silcad batteries, which are one-third the weight and one-fourth the size of ordinary batteries has been issued by **Yardney Electric Corp., Dept. S/A, 40-50 Leonard St., New York 13, N.Y.** The six-page folder includes extensive data on physical and electrical characteristics and lists a variety of applications for the silver-cadium cells. ao-1001-43-S

Write in No. 408 on Reader Service Card

CERAMIC FILTER—A porous ceramic filter element, made from specially formulated glass is described in bulletin GEO-515 issued by **Commercial Filters Corp., Dept. S/A, 2 Main St., Melrose, Mass.** Technical and engineering data, charts, and illustrations are included.

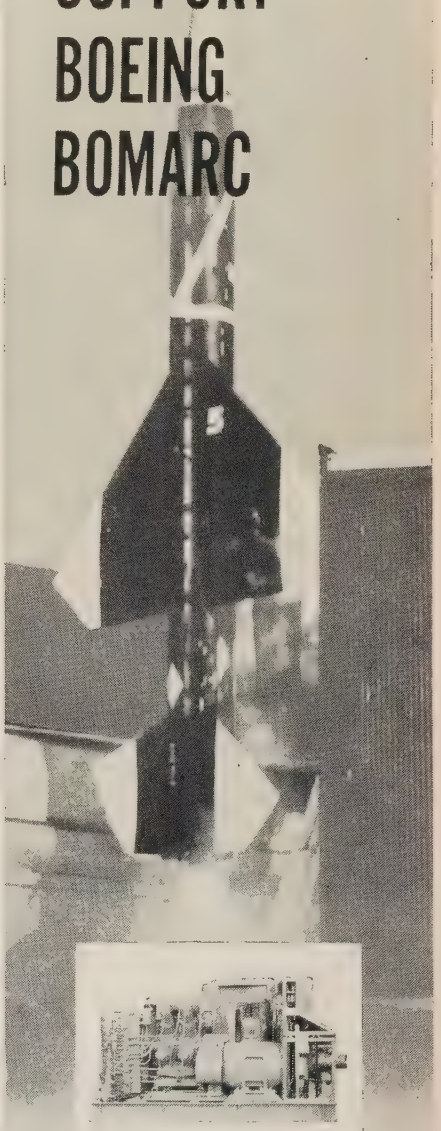
Write in No. 409 on Reader Service Card

RATE GYROS—A 2-page bulletin, No. RG-101, illustrating and describing rate gyros is available from **Humphrey, Inc., Dept. S/A, 2305 Canon St., San Diego 6, Calif.** It provides detailed information on the three rate gyros that cover practically every application requirement.

Write in No. 410 on Reader Service Card

more on page 289

JOY COMPRESSOR FOR GROUND SUPPORT BOEING BOMARC



Joy 80 HES Compressor produces 80 cfm at 5200 psig 75 horsepower

JOY

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Oliver Building • Pittsburgh 22, Pa.

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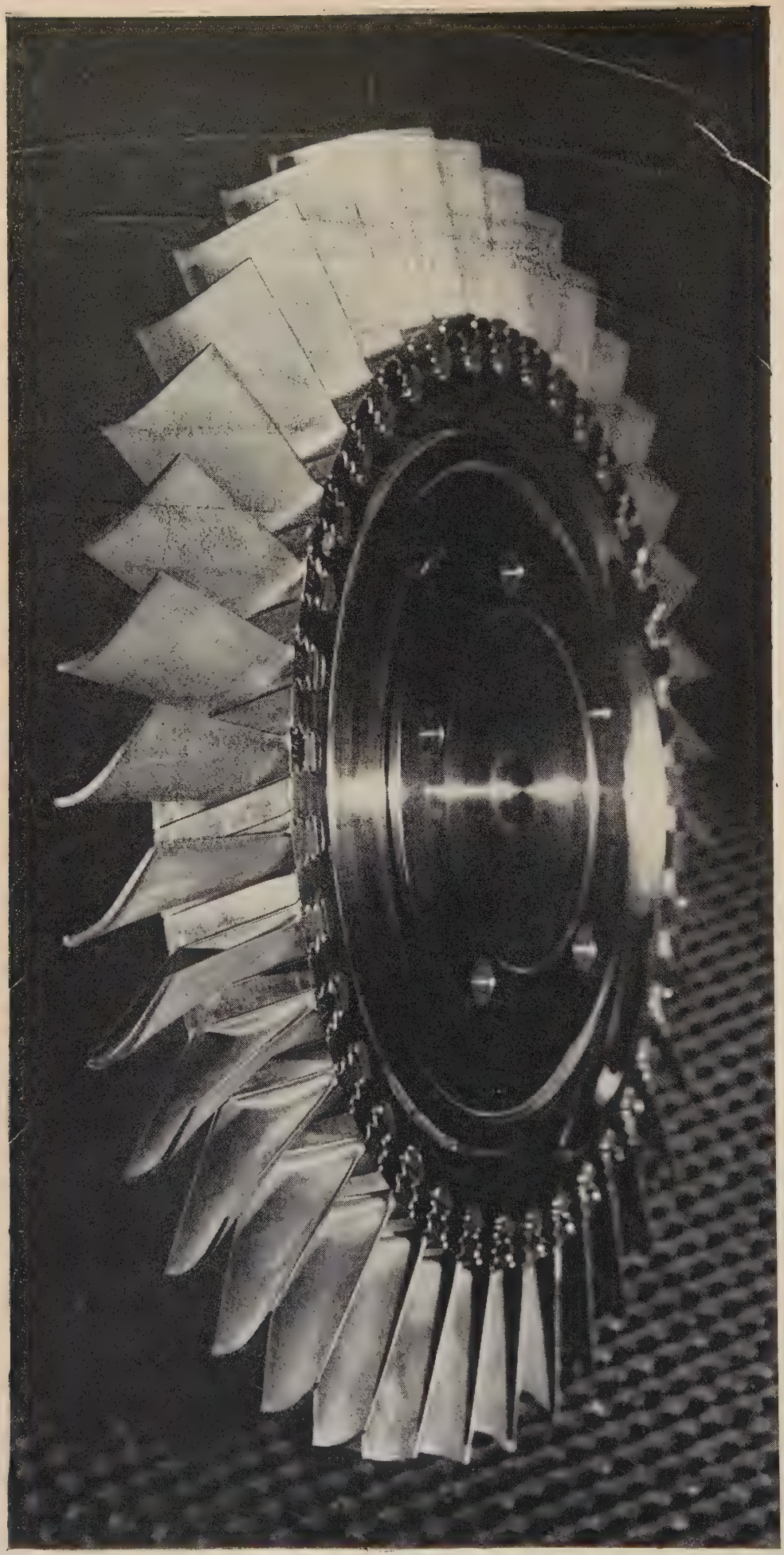


complex jet engine componentry

This complete jet turbine wheel is a product of Kelsey-Hayes, Jackson, Michigan plant.
Its high standards of performance reflect Kelsey-Hayes' capabilities in the production of crucial rotating machinery, components and assemblies.

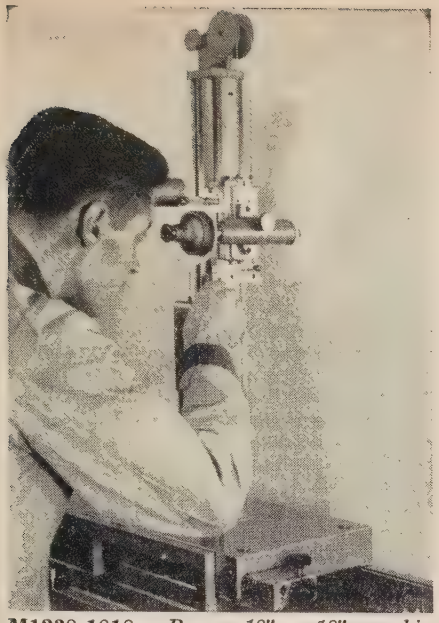
As a major subcontractor to the aerospace industries, Kelsey-Hayes' capabilities also include the production of vacuum-induction-melted alloys, as well as design, development and production of advanced thrust vectoring devices.
Kelsey-Hayes Company,
Detroit 32, Michigan.

KELSEY HAYES COMPANY

Automotive, Aviation and Agricultural Parts
Hand Tools for Industry and Home

18 PLANTS: Detroit and Jackson, Michigan; Los Angeles; Philadelphia and McKeesport, Pennsylvania; Springfield, Ohio; New Hartford and Utica, New York; Davenport, Iowa; Windsor, Ontario, Canada.

Write in No. 231 on Reader Service Card at start of Product Preview Section



M1238-1818 — *Range 18" x 18", working distance 9" to infinity. Reads to 0.001" up to 24" working distance. Protractor ocular reads to 3 minutes of arc. Image is erect.*

Cut inspection time in half

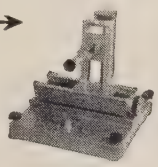
with new Gaertner Coordinate Cathetometers

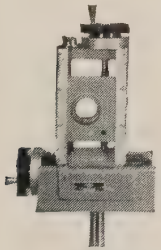
These convenient, reliable optical instruments permit making precise coordinate measurements in a vertical plane. The two dimensions are measured with one setting, object does not have to be rotated. Inspection time is cut in half and resetting errors eliminated.

Versatile Gaertner Coordinate Cathetometers are ideally suited for precision measurements on large objects; also objects or points in recessed, remote, or inaccessible locations. Applications include measuring jet engine sections, complicated castings, printed circuits, bolt holes and bosses on large piece parts, traces on cathode ray tubes, etc.

Because these are optical rather than mechanical measuring instruments, you make non-destructive measurements without contact, distortion, or concern about pressure being applied to the object when making a setting. Instruments available in English or Metric system.

M1236-46— Horizontal range 6", vertical range 4". Reads to 0.0001", working distance 5" to infinity.





M1236-22— Range 2" x 2", reads to 0.0001". Working distance 5" to infinity. Shown with 19 mm mounting rod, and without telemicroscope. Instrument permits precise coordinate movement of other objects such as photo cells, probes, etc., in place of telemicroscope.

Write for Bulletin 188-53

The Gaertner Scientific Corporation

1270 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335

Write in No. 232 on Reader Service Card

PLATINUM PRODUCTS—"Platinum-Group Metals" is an eight-page brochure published to describe the platinum-metal products of **Metals & Controls Div., Texas Instruments, Inc., Dept. S/A, 34 Forest St., Attleboro, Mass.** Among these products are solid and clad platinum metals and alloys in sheet, strip, wire, foil and seamless tubing, catalysts, laboratory ware, rhodium plating solutions, and transistor materials.

Write in No. 411 on Reader Service Card

TEMPERATURE CHAMBERS — Complete specifications on the portable Model FT1 temperature chamber have been included in an information sheet by **Missimers, Inc., Dept. S/A, 3737 San Fernando Rd., Glendale 4, Calif.** Temperature range is —100 to +350 deg F, and the small (35x24x45 in overall) unit will go from room temperature to maximum in 30 min.

Write in No. 412 on Reader Service Card

DRIVE SYSTEM—The Flexidyne dry fluid drive, a controlled acceleration and torque-limiting device designed to protect all kinds of machinery from breakdown because of high inertia starts or sudden overloads, has been described in Bulletin A-640B by **Dodge Mfg. Corp., Dept. S/A, Mishawaka, Ind.** The 24-page catalog offers comprehensive information on the choice of drive sizes and couplings.

Write in No. 413 on Reader Service Card

BRAZING — "Trail Brazing for the Space Age" is a four-page brochure examining the capabilities for pure dry hydrogen brazing of **Western Alloy Engineering Co., Inc., Dept. S/A, 847 Truck Way, Montebello, Calif.** The process is used for copper, silver, nickel, and other alloys.

Write in No. 414 on Reader Service Card

TERMINALS—Signal lead, sealed, glass-to-metal compression terminals are the subject of Bulletin SCT-59-101, available from **Electrical Industries, Dept. S/A, 691 Central Ave., Murray Hill, N. J.** The six-page folder includes a chart designed to aid in the selection of terminal models.

Write in No. 415 on Reader Service Card

HYDRAULIC COMPONENTS—A catalog which discusses hydraulic pneumatic and vacuum data, together with flow charts, JIC piping, and information for engineering and maintenance departments, has been prepared by **Lenz Co., Dept. S/A, Box 1044, Dayton, Ohio.** Included are data on "O" ring seal tube fittings, flare fittings, pipe fittings, tube benders, and other hydraulic components.

Write in No. 416 on Reader Service Card

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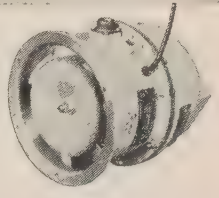
JOY FANS FOR ELECTRONIC COOLING NIKE HERCULES



Fan No. X702-202A
Supplies 300 cfm
at 3" WG pressure
.25 hp

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Oliver Building • Pittsburgh 22, Pa.

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FROM COW PASTURE... TO CANAVERAL!

From the era of the "$2 ride" to today's million dollar blast off's, the success of air vehicle performance has hinged on the reliability of components. Since 1933, Pesco products have been acclaimed for their proven dependability. As man prepares to meet the new challenges of flight, imaginative Pesco engineers are developing new concepts of reliability and . . . through creative engineering . . . are translating them into precision components to deliver volatile fuel, control the flow of hydraulic power, actuate guidance devices, generate and convert precise power, and cool vital working parts. Because today's high mach aircraft demand fail-safe operation, Pesco designs and builds components to *meet and exceed* all anticipated requirements to provide assured performance under critical operating conditions.

PESCO PRODUCTS ASSURE RELIABLE PERFORMANCE FOR AIRCRAFT, MISSILES, AND SPACECRAFT

engineering Pesco production

PESCO BW BORG-WARNER ®

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
24700 North Miles Road • Bedford, Ohio

CONSULT PESCO FIRST FOR
YOUR SPECIALIZED REQUIREMENTS IN . . .

- STATIC INVERTERS
- FREQUENCY CHANGERS
- CRYOGENIC COMPONENTS
- ENVIRONMENTAL COOLING
- AUXILIARY POWER SYSTEMS
- ELECTRIC POWER GENERATION

8791-PC

EXPORT SALES: Borg-Warner International Corp., 36 South Wabash Avenue, Chicago 3, Illinois

Write in No. 234 on Reader Service Card at start of Product Preview Section

SECURITY

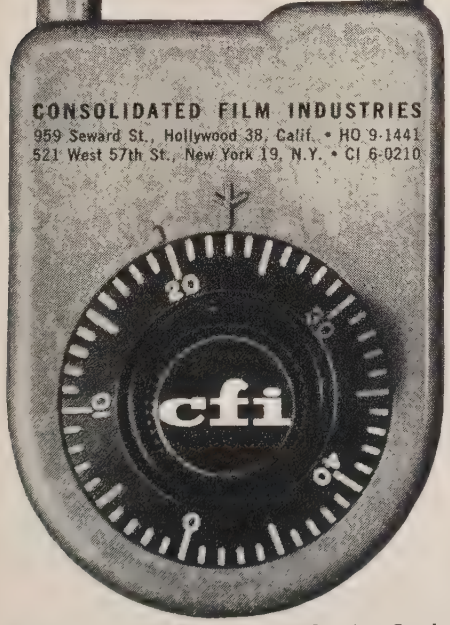
Is classified security a requisite for your film processing? It's guaranteed when you specify Consolidated Film Industries...the nation's leading film processor for over 40 years.

Setting standards for the industry, CFI is still pioneering in the latest security practices. Black and white or color, your test data, training and visual aids films are under stringent security at all times.

For 16 or 35 mm, CFI developed and employs the most modern processing equipment. A broad range of special effects are available to meet every requirement.

CFI does not compromise on quality. Only the finest product receives our Quality Control approval.

CFI, long noted for dependable, fast delivery, serves many major aircraft and missile companies. For your convenience CFI maintains film processing facilities in New York and Hollywood. For the best in service and quality specify CFI. Call or write today for complete information!



CONSOLIDATED FILM INDUSTRIES
959 Seward St., Hollywood 38, Calif. • HO 9-1441
521 West 57th St., New York 19, N.Y. • CI 6-0210

Write in No. 235 on Reader Service Card

DATA PREVIEW

HEATING ELEMENTS—A 12-page catalog, HB-3-359, describes in detail a patented film-type, sprayed-on heating element available from **Electrofilm, Inc., Dept. S/A, P. O. Box 106, N. Hollywood, Calif.** It includes physical, electrical and thermal characteristics, charts and graphs on protective coatings and insulation, temperature rise vs time and all standard terminals.

Write in No. 417 on Reader Service Card

RUBBER PRODUCTS—Industrial rubber products and materials, including silicones, Buna-N, GR-S Synthetic, Neoprene and Teflon, are the subject of a 16-page bulletin available from **Irving B. Moore Corp., Dept. S/A, 65 High St., Boston, Mass.** Data is presented for primary physical properties, comparative properties of natural and synthetic rubbers, reaction of the materials to chemical components, and related military specifications.

Write in No. 418 on Reader Service Card

FLOW MEASUREMENT—A 4 page bulletin, No 2027, describing an automatic channel selecting flow measurement system for range ratios up to 1:1000 has been issued by **George L. Nankervis Co., Cox Instruments Div., Dept. S/A, 15300 Fullerton, Detroit 27, Mich.** It discusses the functions of each of the components of the system and includes dimensional specifications.

Write in No. 419 on Reader Service Card

MULTI-ROTARY SWITCH—Type Jr multiple rotary switch is discussed in data sheet No S-1 issued by **Couch Ordance Inc., 3 Arlington St., N. Quincy 71, Mass.** It provides specifications and design information on 4 separate types with a cross reference to the applicable BuShips drawing number.

Write in No. 420 on Reader Service Card

GAS TURBINE—A catalog sheet describing the lightweight, miniature gas turbine engine has been prepared by the **Curtiss-Wright Corp., Dept. S/A, P. O. Box 689, Santa Barbara, Calif.** Illustrated are turbo-mite engineering details.

Write in No. 421 on Reader Service Card

VIBRATION CONTROL—The application of shock and vibration control devices to military and commercial areas is briefly reviewed in Bulletin 59-05, available from **Barry Controls, Inc., Dept. S/A, 700 Pleasant St., Watertown 72, Mass.** Devices made by the company include isolator systems for electronic devices, machinery mounts, and shock testing units, such as sand drop equipment.

Write in No. 422 on Reader Service Card

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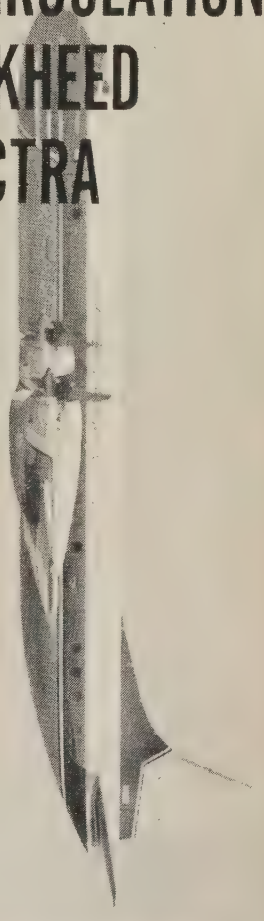
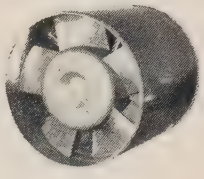
JOY FANS FOR FLIGHT STATION RECIRCULATION LOCKHEED ELECTRA





Fan No. X702-259
Supplies 410 cfm
at 5.1" WGPs
using 0.5 hp

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Oliver Building • Pittsburgh 22, Pa.

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BENDIX RED BANK ANNOUNCES NEW FACILITIES for research, development and production in Safing, Arming, and Fuzing Systems and Components. As systems increase in complexity the need for higher precision in safing, arming, and fuzing grows. To meet this need, Bendix Red Bank Division has created a new department exclusively devoted to design, engineering, and production techniques for these vital systems. ■ This "Special Products Department" is staffed by engineers selected for special abilities in this field. Environmental test equipment and precision tooling enable swift, accurate transition from design to product. Fresh approaches to design and production problems are encouraged by environment conducive to creative thinking. Performance-proved production resources back up new ideas. ■ Since 1941, Bendix Red Bank has grown from a maker of simple electrical devices to a producer of complex electrical and electronic systems. This is added assurance that here your most complex safing, arming, and fuzing problems will receive knowledgeable attention from fundamental analysis through final production.

SPECIAL PRODUCTS DEPARTMENT

Red Bank DIVISION

EATONTOWN, NEW JERSEY

Bendix AVIATION CORPORATION

West Coast Office: 117 E. Providencia, Burbank, Calif. • Export Sales & Service: Bendix International, 205 E. 42nd St., New York 17, N. Y.
Canadian Affiliate: Aviation Elsctric, Ltd., P. O. Box 6102, Montreal, Quebec.

Write in No. 237 on Reader Service Card at start of Product Preview Section

TEST INSTRUMENTS—A 24-page catalog listing the line of integrated instruments for automatic measurement of sound, vibration, and strain has been prepared by **B & K Instruments, Inc., Dept. S/A, 3044 W. 106th St., Cleveland, Ohio.**

Write in No. 423 on Reader Service Card

ALLOYS—Engineering data on eleven cobalt- and iron-base wear-resistant alloys have been consolidated into a new 32-page booklet prepared by **Haynes Stellite Co., Dept. S/A, 420 Lexington Ave., New York 17, N. Y.** In addition to chart presentations of alloy properties, Publication F-30, 133 includes information on heat-treatment, joining, machining, and grinding.

Write in No. 424 on Reader Service Card

CONNECTORS—Catalog 591 offers mechanical, electrical and performance specifications on Spir-O-line coaxial cable and Spir-O-lok connectors made by **Pordelin, Inc., Dept. S/A, 307 Bergen Ave., Kearney, N.J.** Both the semi-flexible, aluminum-sheathed cable and the connectors are air-dielectric devices, and uses extent to the radio, missile guidance and data processing fields, among others.

Write in No. 425 on Reader Service Card

CARTRIDGE STARTER—The Model AS-26 cartridge turbostarter is the subject of Publication GET-2933, a 16-page technical report available from **General Electric Co., Dept. S/A, Schenectady 5, N. Y.** Subjects covered include design approach, performance, propellant section, and individual components of the unit.

Write in No. 426 on Reader Service Card

MAGNETIC CLUTCHES—A complete line of magnetic clutches and clutch brakes has been described in a four-page catalog prepared by **Dynamic Instrument Corp., Dept. S/A, 59 New York Ave., Westbury, L. I., N. Y.** Comprehensive environmental and mechanical specifications are included.

Write in No. 427 on Reader Service Card

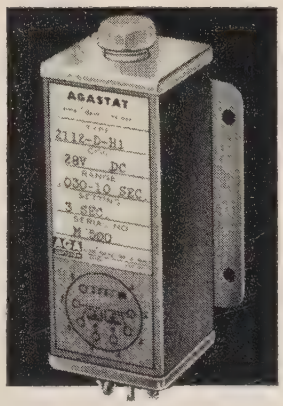
WELDING—The basic application of carbon rods, plate and paste to welding jobs has been described in the "Welding Carbon Products Manual," prepared by **The Arcair Co., Dept. S/A, P.O. Box 431, Lancaster, O.** The carbon products are said to eliminate the need for many jigs and fixtures especially on small jobs.

Write in No. 428 on Reader Service Card

more on page 295

NEW MINIATURE AGASTAT® time delay relay

for missile, aircraft and electronic applications



INSTANTANEOUS RECYCLING . . . reset time—less than .020 seconds

UNAFFECTED BY VOLTAGE VARIATIONS . . . time delay remains constant from 18 to 30 volts DC

ADJUSTABLE . . . time delays from .030 to 120 seconds

CHOICE OF OPERATION . . . for either energizing or de-energizing

SMALL . . . height—4⅝". . . width—1 13/16". . . depth—1½"

LIGHT . . . maximum weight—15 ounces

MEETS ENVIRONMENTAL REQUIREMENTS OF MIL-E-5272A

This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit built to withstand the rugged environmental conditions of missile and aircraft applications.

For specific information on the new AGASTAT relay for your application, write to Dept. A30-219

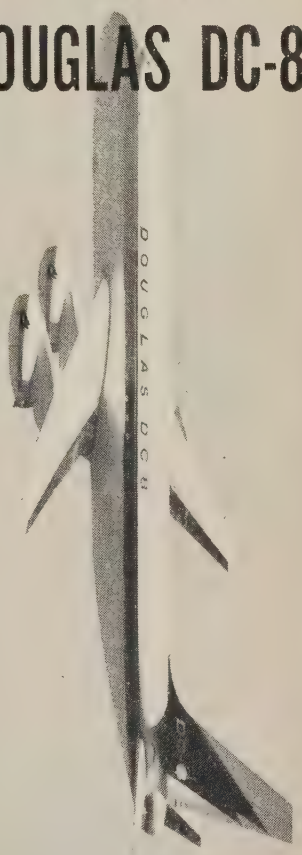
AGA DIVISION **ELASTIC STOP NUT CORPORATION OF AMERICA**

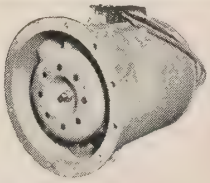
1027 Newark Avenue, Elizabeth, New Jersey

Pioneers in pneumatic timing

Write in No. 238 on Reader Service Card at start of Product Preview Section

JOY FANS FOR CABIN VENTILATION DOUGLAS DC-8





Fan No. X702-256C supplies 2170 at 23.5 WGPs using only 11.0 hp

JOY

Joy Manufacturing Company
Oliver Building • Pittsburgh 22, Pa.

Write in No. 239 on Reader Service Card

a new type
primary standard
for measuring
AC/DC power

INTRODUCING

Model 1483

THE WESTON ELECTRONIC WATTMETER

- Transfer accuracy between DC and AC is within 0.01%
- Unprecedented versatility and reliability

CHECK THESE FEATURES:

- **NEGLIGIBLE STATIC FRICTION** between pivot and jewel bearing to affect accuracy. A small-amplitude vibration is fed constantly to the sensing element—makes possible resolutions down to .01% — 1/5 the resolution of the best indicating meter.
- **NO SPRING FATIGUE** — Springs have been eliminated.
- **TEMPERATURE COMPENSATED** — reduced self-heating errors.
- **LOW EDDY CURRENTS** — due to ferrite shields. Frequency compensated.
- **NO MUTUAL INDUCTANCE ERRORS** — The coils are oriented at 90°.
- **SUSTAINED ACCURACIES DOWN TO 10% POWER-FACTOR.**
- **ONLY ONE POTENTIOMETER** needed for DC Standardization—other wattmeters need two Type K pots, multiplying costs . . . **and errors.**
- **READ-OUT VERSATILITY** — can actuate remote indicators, digital meters; drive strip-chart recorders, integrators; used in parallel or alone.

With the development of its Model 1483 Electronic Wattmeter, Weston now brings to AC and DC power measurement a degree of accuracy which extends even beyond the traditional accuracy of Weston's indicating type dynamometer wattmeters. With quick, precise operation, the Model 1483 provides a low impedance DC output that can be measured by present day highly accurate techniques. Truly, here's a new concept in quality and capability.

For full information, contact your local Weston representative . . . or write to Daystrom-Weston Sales Division, Newark 12, N. J. *In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ont. Export: Daystrom Int'l., 100 Empire St., Newark 12, N. J.*

A DAYSTROM UNIT

WESTON *Instruments*

WORLD LEADER IN MEASUREMENT AND CONTROL

Write in No. 240 on Reader Service Card at start of Product Preview Section

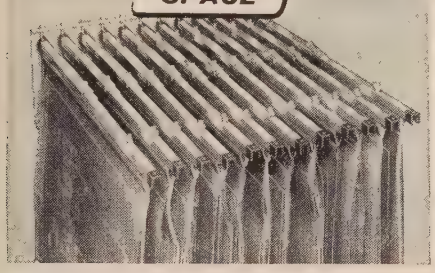
PLAN HOLD.

VERTICAL AND ROLL

Filing Systems

FOR PLANS, PRINTS, DRAWINGS

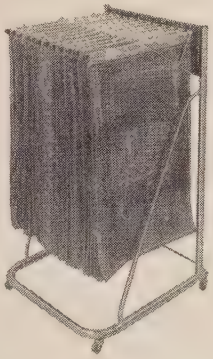
SAVE SPACE



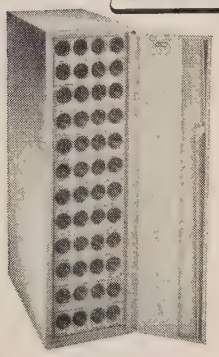
In only 24 lineal inches you can file up to 1200 large sheets. Rack easily mounted on any wall at height determined by length of sheets.

SPEED USE

When plans are used by 2 or more people or departments, the PLAN HOLD Rolling Stand is a great convenience. Glides on ball-bearing casters.



PREVENT DAMAGE



Steel cabinets in modular sizes give extra protection to valuable plans. This Combo Cabinet is equipped with 48 roll file tubes. Also available with vertical files for up to 1200 sheets.

PLAN HOLD equipment brings engineering efficiency to filing and use of all large sheets. Distributed nationally through engineering supply and office equipment dealers. Return coupon for illustrated catalog and prices.

PLAN HOLD CORPORATION
5204 Chakemco St., South Gate, Calif.

Please send catalog No. 602 I am interested in vertical ☐ or roll files ☐.

Your name_____

Company_____

Street_____

City_____ Zone____ State_____

Write in No. 241 on Reader Service Card

DATA PREVIEW

GEARS—Information compiled to assist design engineers in determining basic gear requirements has been presented in Form AD-32, a comprehensive engineering manual issued by **Spiroid Div., Illinois Tool Works, Dept. S/A, 2601 N. Keeler Ave., Chicago 39, Ill.** The manual covers ratings, selections, center distances, bearing loads and other factors, and it illustrates the principle and application of a skew-axis gearing system for medium to high reduction rates.

Write in No. 429 on Reader Service Card

SEALS—A manual for the engineer and designer, which includes engineering data, design relationships and standard size data on the long stroke, deep convolution constant area seals, has been issued by the **Bellofram Corp., Dept. S/A, Burlington, Mass.** It presents a basic description of the seal along with typical applications, typical installation drawings, methods of attachment, installation techniques and standard dimensions.

Write in No. 430 on Reader Service Card

ELECTRIC MOTORS—Two bulletins on its High Power Density line of electric motors have been issued by **Task Corp., Dept. S/A, 1009 E. Vermont Ave., Anaheim, Calif.** One deals with the general characteristics resulting from a design aiming at the maximum ratio of power output to weight, and the other, Bulletin TC-592, concerns a specific example of the design, the Model 249 emergency feathering pump-motor, which is rated at 3.5 hp and weighs 7.2 lbs.

Write in No. 431 on Reader Service Card

VIBRATION TESTING—A brochure that briefly presents the facts and applications of a stroboscopic method of studying repetitive phenomena in slow motion has been issued by **Chadwick Helmuth Co., Dept. S/A, 472 E. Duarte Rd., Monrovia, Calif.** The Slip-Sync method permits display and photographing of rotational, reciprocal or cycle motion, and it can be used for the calibration of accelerometers, among other applications.

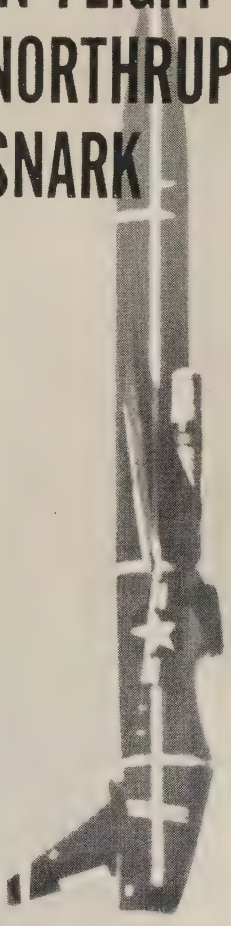
Write in No. 432 on Reader Service Card

TUBING—A revised version of a 14-page tubing and facilities catalog, which covers carbon and alloy seamless steel tubing in mechanical, pressure, aircraft mechanical and airframe grades, has been issued by **Ohio Seamless Tube Div., Copperweld Steel Co., Dept. S/A, Shelby, O.** Catalog CF-3 also includes information on electric welded carbon steel tubing, forging and fabricating operations, and special tubular shapes.

Write in No. 433 on Reader Service Card

more on page 297

JOY FANS FOR ELECTRONIC COOLING IN FLIGHT NORTHRUP SNARK



Fan No. X702-112E
Supplies 3270 cfm
at 7" WGPs
10/6 hp

JOY

Joy Manufacturing Company
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Multi-Use Automated Maintenance

MPTE

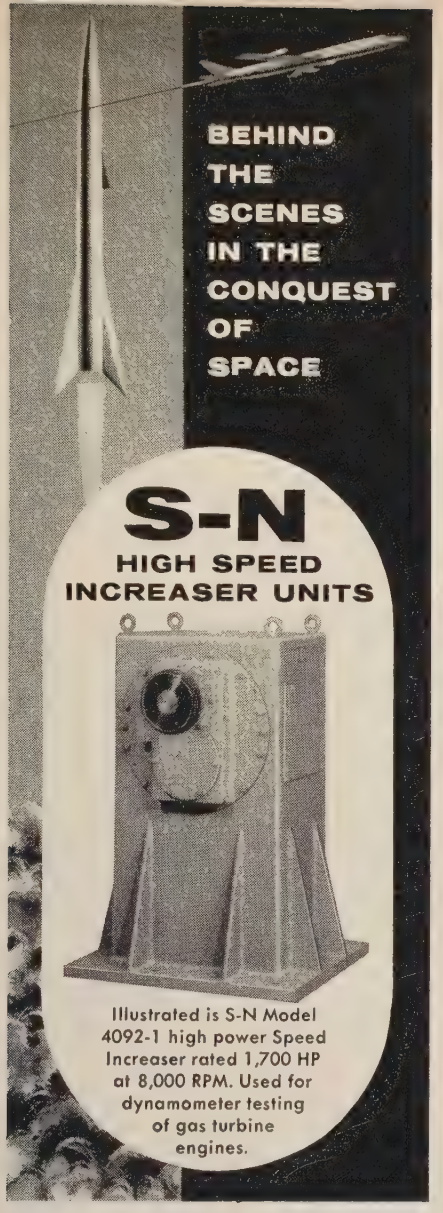
The recent demonstration of multi-purpose test equipment (MPTE), developed by RCA under a series of Army Ordnance contracts, highlights *a new dimension in automated multi-use systems support* and culminates a long-term RCA effort in this field. This General Evaluation Equipment is an automated, transistorized, dynamic checkout system. It contains a completely modularized array of electronic and mechanical evaluation equipment, capable of checking a variety of electromechanical devices, ranging from radar subassemblies to missile guidance computers. MPTE provides the stimuli, programming, control, measurement and test functions for the NIKE AJAX, NIKE HERCULES, LACROSSE, HAWK and CORPORAL missile systems and has been extended to other weapons systems related to our defense efforts.

RCA Tmk(s)®

RADIO CORPORATION of AMERICA

DEFENSE ELECTRONIC PRODUCTS

CAMDEN, NEW JERSEY



Vital to the wondrous advancement of our rockets, missiles, and jets are the grueling tests and checkout of their components on high speed test stands that simulate actual operating conditions during flight. Today, major test installations are equipped with S-N High Speed Gear Increaser Units. Most jets have components checked on S-N equipped high speed test stands.

Whatever your requirements for high speed testing, S-N has a standard unit or will design and build, to your specifications, units from 2 to 2,000 HP to operate at speeds from 80 to 80,000 RPM. They are the product of transmission engineers with over a half century of experience and are built to highest standards of quality. For complete information, write The Snow-Nabstedt Gear Corporation, Hamden, Conn.

SNOW-NABSTEDT

Industrial Division

Transmission Engineers
FOR OVER HALF A CENTURY

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DATA PREVIEW

ROTARY TRANSDUCER—Three-wire construction, high gain and high accuracy are featured in a rotary transducer described in an information sheet available from **G. L. Collins Corp., Dept. S/A, 2820 E. Hullett St., Long Beach 5, Calif.** The RMT-11504 has a linear range of +45 deg, linearity of 0.5 per cent, and phase shift of under five deg, and it operates over a range of —65 to +225 deg F.

Write in No. 434 on Reader Service Card

SYNCHRONOUS MOTOR—A permanent magnet type synchronous motor is the subject of bulletin SS459 issued by **Superior Electric Co., Dept. S/A, Bristol, Conn.** Applications for automatic machines, remote control and numerical control systems are described.

Write in No. 435 on Reader Service Card

HIGH-PURITY METALS—An eight-page technical presentation on the Hopkins Process of metal melting, which results in Stercon H, a high-purity metal for jet engine components and other applications, has been issued by **Firth Sterling, Inc., Dept. S/A, 3113 Forbes Ave., Pittsburgh 30, Pa.** Characteristics of the materials produced by the process include minimum of segregation, uniform physical properties, sonically sound materials, and good surface.

Write in No. 436 on Reader Service Card

TACHOMETERS—Descriptions of the components of several types of electric tachometer systems are contained in a four-page technical bulletin released by **The Electro-Mechano Co., Dept. S/A, 241 E. Erie St., Milwaukee, Wisc.** Six standard types of indicators are covered, along with three models of tachometer generators.

Write in No. 437 on Reader Service Card

TRANSISTORS—A file on transistors that feature fixed-bed construction for exceptional electrical uniformity and stability has been prepared by **General Electric Co., Dept. S/A, 200 Main Ave., Clifton, N.J.** Uses for units described in the ECG 355-2 file include audio and radio frequency range amplifiers, oscillators, and timing and trigger circuits.

Write in No. 438 on Reader Service Card

PRESSES—Construction and operating advantages of the Oliver-Farquhar O.B.I. mechanical gap presses are contained in a 12-page bulletin, M-1000, available from **The Oliver Corp., Dept. S/A, 130 N. Duke St., York, Pa.** Two series, one with an air-operated friction clutch on the back shaft and the other with the clutch on the crank-shaft, are available in 75-, 110-, 150- and 200-ton capacities.

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JOY
WATERPROOF
ELECTRICAL
CONNECTORS
PROVIDE
RUGGED
RELIABILITY
FOR BOMARC

Integral design for dependable performance under the most demanding operating conditions of ground support equipment. Custom-design recommendations and technical assistance on request.

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Quality control at Standard is second to none among the nation's major specialty product steel plants. It is maintained by the most accurate, up-to-date testing equipment available. The laboratory facilities operate around the clock to keep all vital information flowing to our metallurgists, shop foremen, mill and machine operators—as well as to plant management, and, of course, our customers.

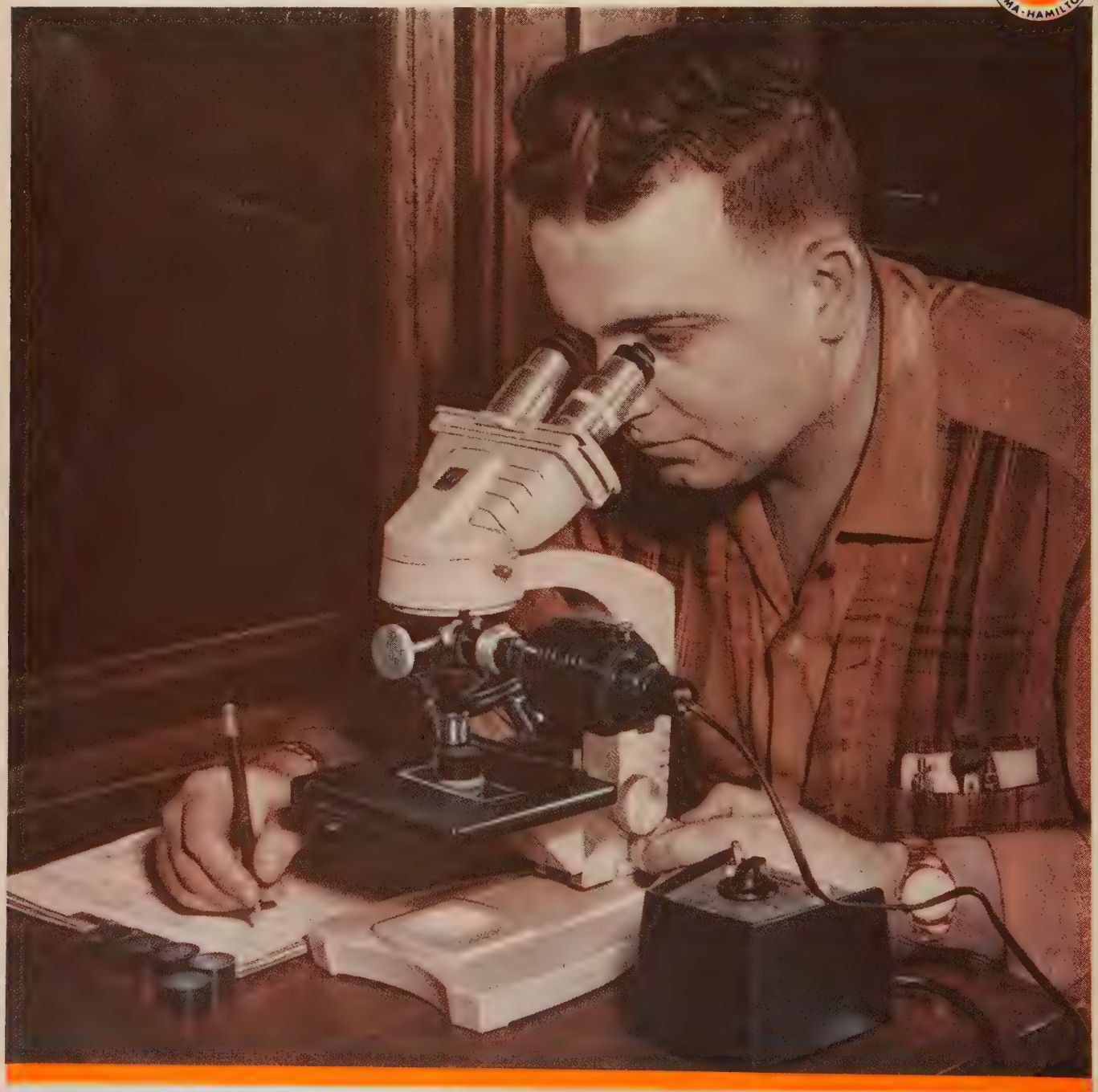
Bring your next unusual product to us—we'll welcome the opportunity to serve you regardless of the alloy it might require. Send for the free illustrated booklet, "Quality Control at Standard."

Standard Steel Works Division

BALDWIN · LIMA · HAMILTON

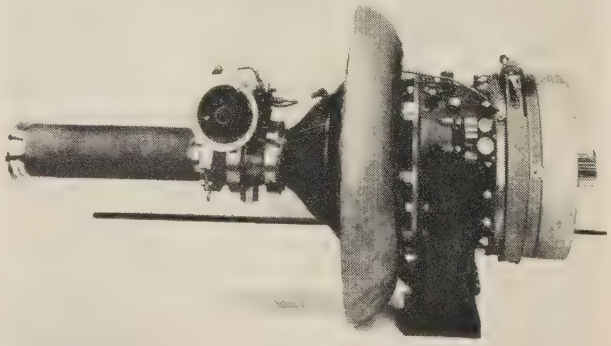
BURNHAM, PENNSYLVANIA

Rings • Shafts • Car wheels • Gear blanks • Flanges • Special shapes

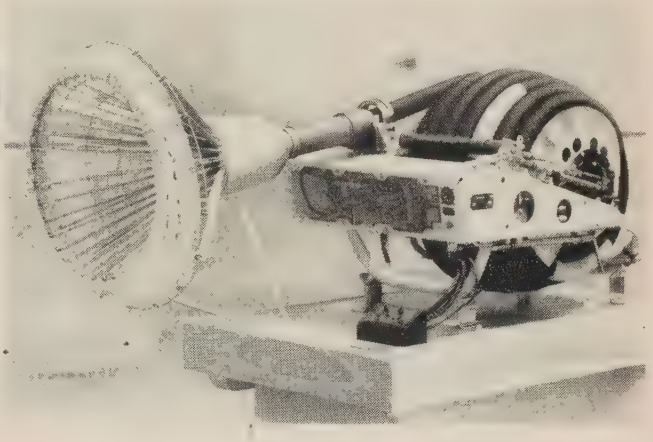


Write in No. 245 on Reader Service Card at start of Product Preview Section

EARLY TEST MODEL of Nike-Zeus anti-missile missile, (above) was successfully test-fired at White Sands, N.M., recently. The Zeus now is in its R&D stage. Right: Fletcher Aviation, of El Monte, Calif., delivered the first production units of its automatic in-flight refueling system for the GV-1 Hercules tanker. The pod-mounted hose reels will operate at speeds up ot 265 KEAS, altitudes up to 35,000 ft, and temperatures as low as —65 deg F.



THIS 500-HP, 150-lb GE starter and motoring unit will be used on an airborne nuclear engine. It will bring the engine's turbomachinery up to self-sustaining speed in about one minute and keep it turning over, or motoring, during long shutdown periods.



Aerojet-General expanded into architectural engineering and electronics with the creation of its new Aetron Division at Covina, Calif. Headed by Benjamin F. Rose Jr., this division combines the company's former architectural-engineering and electronics design groups, which have been bringing in about $15-20 million a year. It employs over 600 people, some 400 of which hold college degrees.

Among the areas in which Aetron will be working are: design and construction of missile testing and launch facilities, manufacturing facilities, nuclear reactor facilities, scientific laboratories, and rocket sled tracks.

Lockheed formed a new subsidiary, Lockheed Electronics Co. (LEC), to be headed by David M. Sanders, formerly president of Stavid Engineering. LEC is made up of Lockheed's former Electronics & Avionics Division (LEAD) and the newly acquired Stavid group. It will have a Stavid Division, in Plainfield, N. J., and a Newport Division, in Newport Beach, Calif. It is planning to put up a new research and production center on a 200-acre site at Newport Beach and a comparable facility in the East. It will also take over LEAD's present Los Angeles plant.

Lockheed president, Courtland S. Gross says his company's aim in setting up LEC "is to attain a balanced market between military and nonmilitary electronics." LEC will not curtail the in-house electronic activities of other Lockheed divisions, he explains.

GE's Small Aircraft Engine Dept., in Lynn, Mass., made drastic changes in its management setup, putting each of its present four engine programs under a project manager. Two of the engines are in production: the T58 turboshaft (D. C. Gerry) and the J85 turbojet (F. O. MacFee). The CF700 turbofan (J. N. Krebs) will go into test this year, while the T64 turboshaft (E. Woll) is in advanced development.

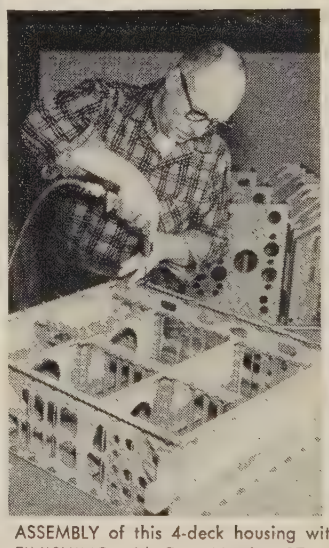
Explaining the reorganization, GE points out that the Small Aircraft Engine Dept. has become a "mature production facility." According to departmental general manager Gerhard Neumann, during 1960 the emphasis at Lynn will shift from design and development to sales and production.

more on page 301

DOW *Now in magnesium and aluminum*

WELDING. Heliarc welding joins parts of this control central case. Dow facilities and personnel for welding are government certified.

DRAWING. This gyro cover is drawn in a single operation. It replaces a part which consisted of welded components.



ASSEMBLY of this 4-deck housing with rivets, bolts and welds precedes FINISHING with Dow Number 17 anodic treatment.

DOW FABRICATION PLANT SAVES WEIGHT, TIME, COSTS ON ICBM COMPUTER HOUSINGS

Working closely with the customer, Dow engineers suggested design modifications for a three-deck computer housing that yielded improvements in both production and application.

Over-all production costs were lowered 20%-30%, compared to the original design. Per-unit tooling costs were also lowered. The new design resulted in better load distribution and increased interchangeability of parts. Delivery schedules were speeded.

The use of magnesium permitted a weight savings of approximately one-third, weld joint efficiencies of 85% and more, and excellent resistance to thermal shock. The high damping capacity of magnesium alleviates vibration considerably.

Because we are working in both magnesium and aluminum, The Dow Metal Products Company can offer the best solution to weight problems. Dow's experience, plant facilities and quality control system have helped many firms solve tough application problems. Production capacity is now available for fabricated parts and assemblies of magnesium, aluminum and other metals.

For more information contact your Dow Sales Office or write today for illustrated brochure describing Dow fabrication facilities and services. THE DOW METAL PRODUCTS COMPANY, Midland, Michigan, Merchandising Dept. 1040EW2.

DOW **THE DOW METAL PRODUCTS COMPANY**

DIVISION OF THE DOW CHEMICAL COMPANY

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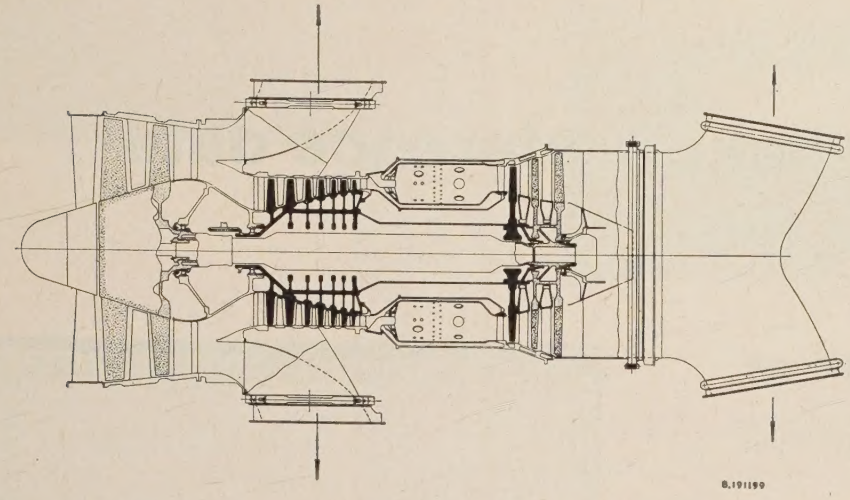
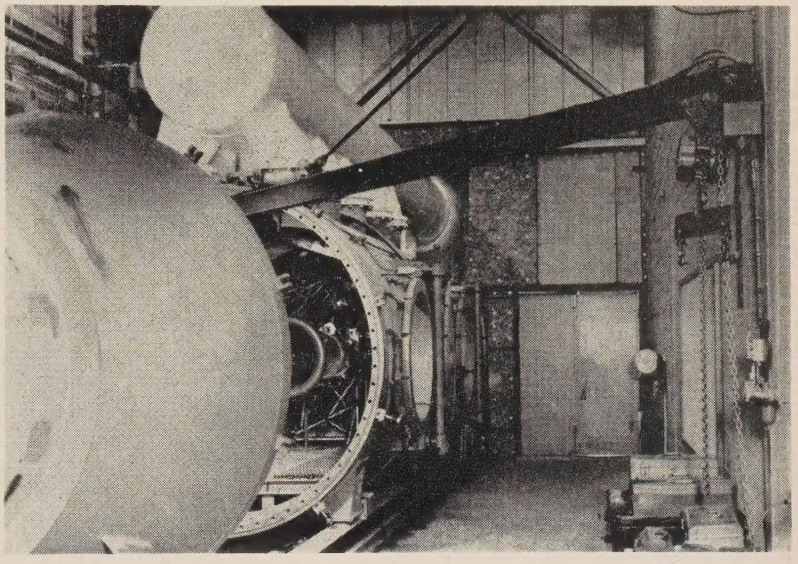


BRISTOL claims its BE-53 ducted-fan jet can power a single-seat fighter during both VTOL and normal forward flight. The engine's jet can be deflected either downward or in any inclined position up to the horizontal. The air flow from the ducted fan in front is channeled into two ducts at the sides of the engine, as is the exhaust flow. The ducts in turn end in directional nozzles.

Aerotest Laboratories, of College Point, N.Y., set up an Advanced Propulsion Division, whose services are offered to all engine and equipment manufacturers and to government agencies. The new division's activities will be centered around the gas turbine lab at Deer Park, N.Y., formerly operated by Fairchild's Engine Div. and recently acquired by Aerotest Labs. The *Photo* shows the altitude chamber of the gas turbine lab, which Aerotest calls "the only facility of its type and size in operation by [an] independent [U.S.] test laboratory."



Convair-Astronautics let a $276,633 contract for the construction of an "engineering space research lab." The new building will have two vacuum tanks 12 ft in diameter and 20 ft long for the simulation of space and near-space environments. It will have more than 18,000 sq ft of floor area.

To handle Minuteman production, USAF will build a new plant and modify another. At the new facility in Brigham City, Utah, Thiokol will produce the missile's first-stage solid rocket; Boeing will use the former ordnance plant near Ogden, Utah, for the assembly and maintenance of the complete missile.

Motorola bought Lear's lightplane products business, made up of airborne navigation, communications, and lightplane autopilots produced by LearCal. Lear retained the right to continue making transport and military autopilots, flight controls, and instruments.

How to "shake" reference data from your file

by H. Bloom, M. Kornhauser and C. Odenweller,
Systems Engineer, Systems Project Engineer, & Systems Analysis Engineer, resp., Missile & Space Vehicle Dept., General Electric Co.*

HOW TO KEEP an easily usable file of abstracts on reference material is a problem that has plagued engineers for many years. The standard 3x5 file of cards is only part of the answer, for how do you quickly find a specific set of cards in such a file?

Using standard manual equipment, the Advance Space Vehicle Engineering Operation (ASVEO) at GE's Missile & Space Vehicle Dept. has set up a simple file system that nevertheless meets the complex information needs of its systems engineers. Only one card is required per reference, no matter how many subjects are covered in the reference. The cards can be filed at random, yet all cards pertaining to a given subject can be pulled from among several hundred others in a matter of seconds.

Our file system has only four parts, all of them cheap. Supplied by Royal McBee, they are: (1) a card file cabinet; (2) Keysort cards, with some 90 holes punched out around the edges of each card; (3) a hand punch; and (4) a Keysorter, which is simply a hand-held spike.

To use the file system, you start out by making up an index of subjects, assigning a key (such as a number) to each subject, and entering the keys underneath the holes on each card. In actual filing you then:

(1) enter on a blank card the data on the reference, or paste on an abstract like the ones found in SPACE/AERONAUTICS' "In This Issue" section;

(2) punch the card at the holes whose numbers correspond to the subjects covered in the reference, so that at these numbers there are now notches;

(3) place the card anywhere in the file drawer, making sure only that the card's clipped edge is at the upper left.

To find all the cards covering references on a given subject:

(1) look up the hole number in the index of subjects;

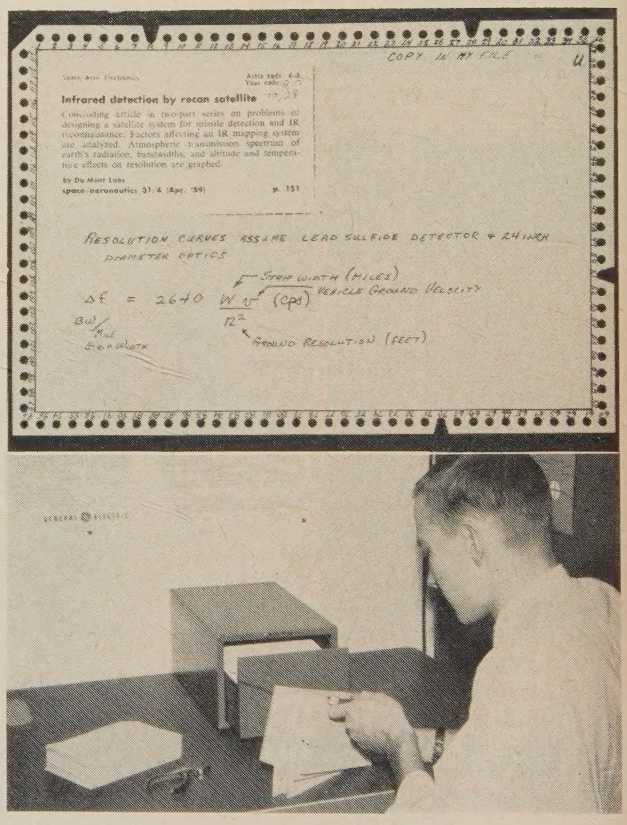
(2) lift out a stack of cards and insert the Keysorter in the hole whose number you have looked up;

(3) shake the stack of cards on the Keysorter;

(4) gather the cards that fall out, since these cover references you are looking for;

(5) repeat for all other cards in the file.

Color coding can be added to the notching to refine your subject breakdown. Three or four colors under a code number obviously triples or quadruples the number of subjects that can be filed per hole. In filing, the proper color is then applied by crayon around and in the notch.


COPY IN MY FILE
Infrared detection by recon satellite
RESOLUTION CURVES ASSUME LEAD SULFIDE DETECTOR & 24 INCH DIAMETER OPTICS
STRIP WIDTH (MILES)
VEHICLE GROUND VELOCITY
GROUND RESOLUTION (FEET)

TO FIND all the cards on a given subject, you take a stack of cards, stick the Keysorter spike through the hole with the number of the subject you are looking for, and shake. All the cards notched at this number will promptly fall out.

Contributions to this department may be on any subject, technical or nontechnical, about which readers would like to air their views. Names and professional affiliations will be withheld on request.

* Missile & Space Vehicle Dept., General Electric Co., 3198 Chestnut St., Philadelphia 4, Pa.

Portraits of PERFORMANCE

Two rousing tributes to the performance reliability of CECO products are the remarkable records being compiled by the jet airliners pictured above in "gallery display"—the Boeing 707 and Douglas DC-8.

Main fuel pumps for the Pratt & Whitney Aircraft engines powering each were engineered and precision-produced by Chandler Evans. Significantly, during the first exciting year of U.S. commercial jet operation, CECO pumps took part in every single service mile flown by either type of aircraft.

If pictures of missiles and aircraft which are airborne with CECO products actually *were* exhibited in a gallery, the section devoted to pump applications would be an impressive one. In addition, space would have to be set aside for future portraits, since right now . . . at Chandler Evans . . . a number of important pump design and development programs are underway.

CECO® SYSTEMS CONTROLS

CHANDLER EVANS CORPORATION

West Hartford 1, Connecticut

Interesting, informative literature on many CECO products is yours for the asking. Please address your request to Dept. 10.

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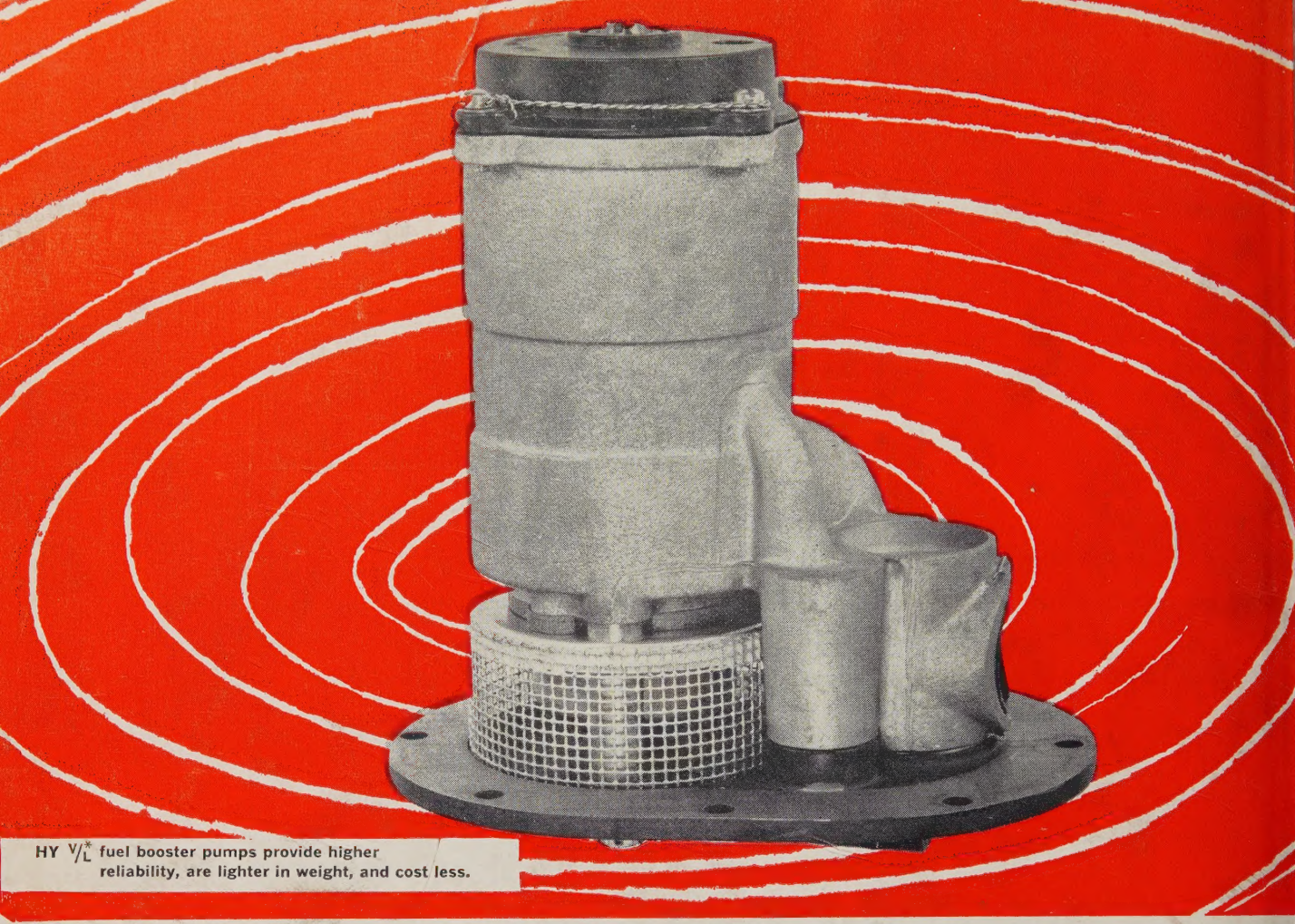

HY V/L* fuel booster pumps provide higher reliability, are lighter in weight, and cost less.

Still *Another* Hydro-Aire Product for the *Aircraft* and *Missile* Industries

The Hydro-Aire fuel booster pump shown above is typical of a universally accepted family of pumps—known around the world—flown around the world. As used in jet fighters, bombers, and missiles, this pump is lighter—weighing only 6.8 pounds—is lower in cost, has proven much more reliable. It pumps 20,000 pounds of fuel per hour at 16 psig minimum. Ambient temperature range is —65°F to 250°F at sea level to 100,000 ft. altitude. These units consistently demonstrate excellent dry running, vapor and ice handling characteristics.

Attention: Fuel System Designers

Hydro-Aire can supply pumps, subsystems or systems to handle Avgas, JP fuel, water, alcohol, liquid nitrogen, liquid oxygen, hydraulic oil and engine oil. They can be supplied electric motor driven, hydraulic motor driven, engine driven or turbine driven.

Send your requirements or write for information.

Engineers: Interesting opportunities are available. Write or call Mr. Douglas Nickerson, Chief Engineer, 3000 Winona Avenue, Burbank.

*high vapor/liquid ratio

HYDRO-AIRE
BURBANK, CALIFORNIA
Division of CRANE CO.
Developers and producers of reliable control components, sub-systems and systems for aircraft, missiles, electronics, transportation and general industry.

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